OcNOS®

Open Compute Network Operating System for Service Providers Version 6.6.0

Multi-Protocol Label Switching Guide

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IP Infusion Inc.

3979 Freedom Circle

Suite 900

Santa Clara, California 95054

http://www.ipinfusion.com/

For support, questions, or comments via E-mail, contact:

support@ipinfusion.com

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Preface

This guide describes how to configure OcNOS.

IP Maestro Support

Monitor devices running OcNOS Release 6.3.4-70 and above using IP Maestro software.

Audience

This guide is intended for network administrators and other engineering professionals who configure OcNOS.

Conventions

Table 1 on page 33 shows the conventions used in this guide.

Table 1: Conventions

Convention	Description
Italics	Emphasized terms; titles of books
Note:	Special instructions, suggestions, or warnings
`monospaced type`	Code elements such as commands, parameters, files, and directories

Chapter Organization

The chapters in command references are organized as described in Command Description Format.

The chapters in configuration guides are organized into these major sections:

- An overview that explains a configuration in words
- Topology with a diagram that shows the devices and connections used in the configuration
- Configuration steps in a table for each device where the left-hand side shows the commands you enter and the right-hand side explains the actions that the commands perform
- Validation which shows commands and their output that verify the configuration

Related Documentation

For information about installing OcNOS, see the *Installation Guide* for your platform.

Feature Availability

The features described in this document that are available depend upon the OcNOS SKU that you purchased. See the *Feature Matrix* for a description of the OcNOS SKUs.

Migration Guide

Check the *Migration Guide* for configuration changes to make when migrating from one version of OcNOS to another.

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Command Line Interface

This chapter introduces the OcNOS Command Line Interface (CLI) and how to use its features.

Overview

You use the CLI to configure, monitor, and maintain OcNOS devices. The CLI is text-based and each command is usually associated with a specific task.

You can give the commands described in this manual locally from the console of a device running OcNOS or remotely from a terminal emulator such as `putty` or `xterm`. You can also use the commands in scripts to automate configuration tasks.

Command Line Interface Help

You access the CLI help by entering a full or partial command string and a question mark "?". The CLI displays the command keywords or parameters along with a short description. For example, at the CLI command prompt, type:

```
> show ?
```

The CLI displays this keyword list with short descriptions for each keyword:

```
show ?
  application-priority             Application Priority
  arp                              Internet Protocol (IP)
  bfd                              Bidirectional Forwarding Detection (BFD)
  bgp                              Border Gateway Protocol (BGP)
  bi-lsp                           Bi-directional lsp status and configuration
  bridge                           Bridge group commands
  ce-vlan                          COS Preservation for Customer Edge VLAN
  class-map                        Class map entry
  cli                              Show CLI tree of current mode
  clns                             Connectionless-Mode Network Service (CLNS)
  control-adjacency                Control Adjacency status and configuration
  control-channel                  Control Channel status and configuration
  cspf                             CSPF Information
  customer                         Display Customer spanning-tree
  cvlan                            Display CVLAN information
  debugging                        Debugging functions
  etherchannel                     LACP etherchannel
  ethernet                         Layer-2
...
```

If you type the ? in the middle of a keyword, the CLI displays help for that keyword only.

```
> show de?
debugging  Debugging functions
```

If you type the ? in the middle of a keyword, but the incomplete keyword matches several other keywords, OcNOS displays help for all matching keywords.

```
> show i? (CLI does not display the question mark).
interface  Interface status and configuration
ip         IP information
isis       ISIS information
```

Command Completion

The CLI can complete the spelling of a command or a parameter. Begin typing the command or parameter and then press the tab key. For example, at the CLI command prompt type `sh`:

```
> sh
```

Press the tab key. The CLI displays:

```
> show
```

If the spelling of a command or parameter is ambiguous, the CLI displays the choices that match the abbreviation. Type `show i` and press the tab key. The CLI displays:

```
> show i
  interface  ip          ipv6       isis
> show i
```

The CLI displays the `interface` and `ip` keywords. Type `n` to select `interface` and press the tab key. The CLI displays:

```
> show in
> show interface
```

Type ? and the CLI displays the list of parameters for the `show interface` command.

```
> show interface
  IFNAME  Interface name
  |       Output modifiers
  >       Output redirection
  <cr>
```

The CLI displays the only parameter associated with this command, the `IFNAME` parameter.

Command Abbreviations

The CLI accepts abbreviations that uniquely identify a keyword in commands. For example:

```
> sh int xe0
```

is an abbreviation for:

```
> show interface xe0
```

Command Line Errors

Any unknown spelling causes the CLI to display the error `Unrecognized command` in response to the ?. The CLI displays the command again as last entered.

```
> show dd?
% Unrecognized command
> show dd
```

When you press the Enter key after typing an invalid command, the CLI displays:

```
(config)#router ospf here
                          ^
% Invalid input detected at '^' marker.
```

where the ^ points to the first character in error in the command.

If a command is incomplete, the CLI displays the following message:

```
> show
% Incomplete command.
```

Some commands are too long for the display line and can wrap mid-parameter or mid-keyword, as shown below. This does *not* cause an error and the command performs as expected:

```
area 10.10.0.18 virtual-link 10.10.0.19 authent
ication-key 57393
```

Command Negation

Many commands have a `no` form that resets a feature to its default value or disables the feature. For example:

- The `ip address` command assigns an IPv4 address to an interface
- The `no ip address` command removes an IPv4 address from an interface

Syntax Conventions

Table 2 on page 37 describes the conventions used to represent command syntax in this reference.

Table 2: Syntax conventions

Convention	Description	Example
`monospaced font`	Command strings entered on a command line	`show ip ospf`
`lowercase`	Keywords that you enter exactly as shown in the command syntax.	`show ip ospf`
`UPPERCASE`	See Variable Placeholders	`IFNAME`
`()`	Optional parameters, from which you must select one. Vertical bars delimit the selections. Do not enter the parentheses or vertical bars as part of the command.	`(A.B.C.D|<0-4294967295>)`
`()`	Optional parameters, from which you select one or none. Vertical bars delimit the selections. Do not enter the parentheses or vertical bars as part of the command.	`(A.B.C.D|<0-4294967295>|)`
`()`	Optional parameter which you can specify or omit. Do not enter the parentheses or vertical bar as part of the command.	`(IFNAME|)`
`{}`	Optional parameters, from which you must select one or more. Vertical bars delimit the selections. Do not enter the braces or vertical bars as part of the command.	`{intra-area <1-255>|inter-area <1-255>|external <1-255>}`

Table 2: Syntax conventions (Continued)

Convention	Description	Example
`[]`	Optional parameters, from which you select zero or more. Vertical bars delimit the selections. Do not enter the brackets or vertical bars as part of the command.	`[<1-65535>|AA:NN|internet|local-AS|no-advertise|no-export]`
`?`	Nonrepeatable parameter. The parameter that follows a question mark can only appear once in a command string. Do not enter the question mark as part of the command.	`?route-map WORD`
`.`	Repeatable parameter. The parameter that follows a period can be repeated more than once. Do not enter the period as part of the command.	`set as-path prepend .<1-65535>`

Variable Placeholders

Table 3 on page 38 shows the tokens used in command syntax use to represent variables for which you supply a value.

Table 3: Variable placeholders

Token	Description
`WORD`	A contiguous text string (excluding spaces)
`LINE`	A text string, including spaces; no other parameters can follow this parameter
`IFNAME`	Interface name whose format varies depending on the platform; examples are: `eth0`, `Ethernet0`, `ethernet0`, `xe0`
`A.B.C.D`	IPv4 address
`A.B.C.D/M`	IPv4 address and mask/prefix
`X:X::X:X`	IPv6 address
`X:X::X:X/M`	IPv6 address and mask/prefix
`HH:MM:SS`	Time format
`AA:NN`	BGP community value
`XX:XX:XX:XX:XX:XX`	MAC address

`<1-5>`
`<1-65535>`
`<0-2147483647>`
`<0-4294967295>`
	Numeric range

Command Description Format

Table 4 on page 39 explains the sections used to describe each command in this reference.

Table 4: Command descriptions

Section	Description
Command Name	The name of the command, followed by what the command does and when should it be used
Command Syntax	The syntax of the command
Parameters	Parameters and options for the command
Default	The state before the command is executed
Command Mode	The mode in which the command runs; see Command Modes
Example	An example of the command being executed

Keyboard Operations

Table 5 on page 39 lists the operations you can perform from the keyboard.

Table 5: Keyboard operations

Key combination	Operation
Left arrow or Ctrl+b	Moves one character to the left. When a command extends beyond a single line, you can press left arrow or Ctrl+b repeatedly to scroll toward the beginning of the line, or you can press Ctrl+a to go directly to the beginning of the line.
Right arrow or Ctrl-f	Moves one character to the right. When a command extends beyond a single line, you can press right arrow or Ctrl+f repeatedly to scroll toward the end of the line, or you can press Ctrl+e to go directly to the end of the line.
Esc, b	Moves back one word
Esc, f	Moves forward one word
Ctrl+e	Moves to end of the line
Ctrl+a	Moves to the beginning of the line
Ctrl+u	Deletes the line
Ctrl+w	Deletes from the cursor to the previous whitespace
Alt+d	Deletes the current word
Ctrl+k	Deletes from the cursor to the end of line
Ctrl+y	Pastes text previously deleted with Ctrl+k, Alt+d, Ctrl+w, or Ctrl+u at the cursor

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Table 5: Keyboard operations (Continued)

Key combination	Operation
Ctrl+t	Transposes the current character with the previous character
Ctrl+c	Ignores the current line and redisplays the command prompt
Ctrl+z	Ends configuration mode and returns to exec mode
Ctrl+l	Clears the screen
Up Arrow or Ctrl+p	Scroll backward through command history
Down Arrow or Ctrl+n	Scroll forward through command history

Show Command Modifiers

You can use two tokens to modify the output of a `show` command. Enter a question mark to display these tokens:

```
# show users ?
  | Output modifiers
  > Output redirection
```

You can type the | (vertical bar character) to use output modifiers. For example:

```
> show rsvp | ?
  begin     Begin with the line that matches
  exclude   Exclude lines that match
  include   Include lines that match
  last      Last few lines
  redirect  Redirect output
```

Begin Modifier

The `begin` modifier displays the output beginning with the first line that contains the input string (everything typed after the `begin` keyword). For example:

```
# show running-config | begin xe1
...skipping
interface xe1
 ipv6 address fe80::204:75ff:fee6:5393/64
!
interface xe2
 ipv6 address fe80::20d:56ff:fe96:725a/64
!
line con 0
 login
!
end
```

You can specify a regular expression after the `begin` keyword, This example begins the output at a line with either “xe2” or “xe4”:

```
# show running-config | begin xe[2-4]

...skipping
```

```
interface xe2
 shutdown
!
interface xe4
 shutdown
!
interface svlan0.1
 no shutdown
!
route-map myroute permit 2
!
route-map mymap1 permit 10
!
route-map rmap1 permit 2
!
line con 0
 login
line vty 0 4
 login
!
end
```

Include Modifier

The `include` modifier includes only those lines of output that contain the input string. In the output below, all lines containing the word "input" are included:

```
# show interface xe1 | include input
    input packets 80434552, bytes 2147483647, dropped 0, multicast packets 0
    input errors 0, length 0, overrun 0, CRC 0, frame 0, fifo 1, missed 0
```

You can specify a regular expression after the `include` keyword. This examples includes all lines with "input" or "output":

```
#show interface xe0 | include (in|out)put
    input packets 597058, bytes 338081476, dropped 0, multicast packets 0
    input errors 0, length 0, overrun 0, CRC 0, frame 0, fifo 0, missed 0
    output packets 613147, bytes 126055987, dropped 0
    output errors 0, aborted 0, carrier 0, fifo 0, heartbeat 0, window 0
```

Exclude Modifier

The `exclude` modifier excludes all lines of output that contain the input string. In the following output example, all lines containing the word "input" are excluded:

```
# show interface xe1 | exclude input
Interface xe1
  Scope: both
  Hardware is Ethernet, address is 0004.75e6.5393
  index 3 metric 1 mtu 1500 <UP,BROADCAST,RUNNING,MULTICAST>
  VRF Binding: Not bound
  Administrative Group(s): None
  DSTE Bandwidth Constraint Mode is MAM
  inet6 fe80::204:75ff:fee6:5393/64
    output packets 4438, bytes 394940, dropped 0
    output errors 0, aborted 0, carrier 0, fifo 0, heartbeat 0, window 0
    collisions 0
```

You can specify a regular expression after the `exclude` keyword. This example excludes lines with “output” or “input”:

```
# show interface xe0 | exclude (in|out)put
Interface xe0
  Scope: both
  Hardware is Ethernet  Current HW addr: 001b.2139.6c4a
  Physical:001b.2139.6c4a  Logical:(not set)
  index 2 metric 1 mtu 1500 duplex-full arp ageing timeout 3000
  <UP,BROADCAST,RUNNING,MULTICAST>
  VRF Binding: Not bound
  Bandwidth 100m
  DHCP client is disabled.
  inet 10.1.2.173/24 broadcast 10.1.2.255
  VRRP Master of :  VRRP is not configured on this interface.
  inet6 fe80::21b:21ff:fe39:6c4a/64
    collisions 0
```

Redirect Modifier

The `redirect` modifier writes the output into a file. The output is not displayed.

```
# show cli history | redirect /var/frame.txt
```

The output redirection token (>) does the same thing:

```
# show cli history >/var/frame.txt
```

Last Modifier

The `last` modifier displays the output of last few number of lines (As per the user input). The last number ranges from 1 to 9999.

For example:

```
#show running-config | last 10
```

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String Parameters

The restrictions in Table 6 on page 43 apply for all string parameters used in OcNOS commands, unless some other restrictions are noted for a particular command.

Table 6: String parameter restrictions

Restriction	Description
Input length	1965 characters or less
Restricted special characters	"?", ",", ">", "|", and "=" The "|" character is allowed only for the `description` command in interface mode.

Command Modes

Commands are grouped into modes arranged in a hierarchy. Each mode has its own set of commands. Table P-7 lists the command modes common to all protocols.

Table 7: Common command modes

Name	Description
Executive mode	Also called *view* mode, this is the first mode to appear after you start the CLI. It is a base mode from where you can perform basic commands such as `show`, `exit`, `quit`, `help`, and `enable`.
Privileged executive mode	Also called *enable* mode, in this mode you can run additional basic commands such as `debug`, `write`, and `show`.
Configure mode	Also called *configure terminal* mode, in this mode you can run configuration commands and go into other modes such as interface, router, route map, key chain, and address family. Configure mode is single user. Only one user at a time can be in configure mode.
Interface mode	In this mode you can configure protocol-specific settings for a particular interface. Any setting you configure in this mode overrides a setting configured in router mode.
Router mode	This mode is used to configure router-specific settings for a protocol such as BGP or OSPF.

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Command Mode Tree

The diagram below shows the common command mode hierarchy.

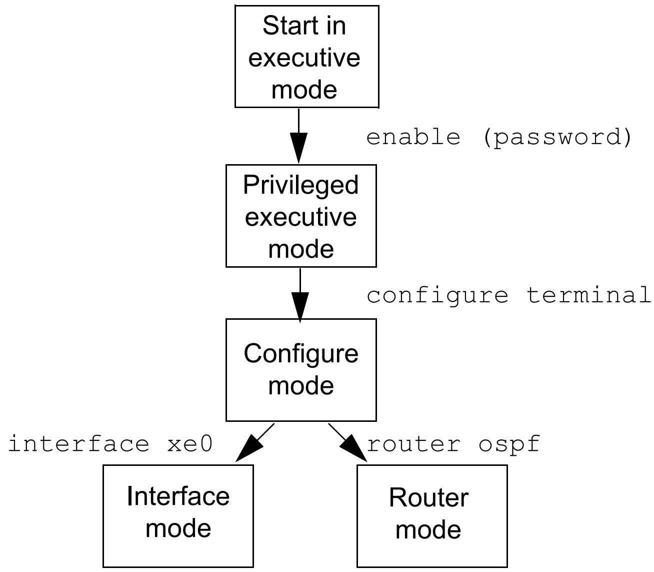

Figure P-1: Common command modes

To change modes:

1. Enter privileged executive mode by entering `enable` in Executive mode.

2. Enter configure mode by entering `configure terminal` in Privileged Executive mode.

The example below shows moving from executive mode to privileged executive mode to configure mode and finally to router mode:

```
> enable mypassword
# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
(config)# router ospf
(config-router)#
```

Note: Each protocol can have modes in addition to the common command modes. See the command reference for the respective protocol for details.

Transaction-based Command-line Interface

The OcNOS command line interface is transaction based:

- Any changes done in configure mode are stored in a separate *candidate* configuration that you can view with the `show transaction current` command.
- When a configuration is complete, apply the candidate configuration to the running configuration with the `commit` command.
- If a `commit` fails, no configuration is applied as the entire transaction is considered failed. You can continue to change the candidate configuration and then retry the `commit`.
- Discard the candidate configuration with the `abort transaction` command.
- Check the last aborted transaction with the `show transaction last-aborted` command.
- Multiple configurations cannot be removed with a single `commit` . You must remove each configuration followed by a `commit`

Note: All commands MUST be executed only in the default CML shell (`cmlsh`). If you log in as root and start `imish`, then the system configurations will go out of sync. The `imish` shell is not supported and should not be started manually.

Ethernet Virtual Private Network Configuration

CHAPTER 1 EVPN MPLS Configuration

This chapter includes step-by-step configurations for EVPN MPLS for Single Homing and Multi Homing.

Overview

Ethernet VPN (EVPN) solution provides Ethernet multipoint services over MPLS networks. EVPN operates in contrast to the existing Virtual Private LAN Service (VPLS) by enabling control-plane based MAC learning. PEs participating in the EVPN instances learn customer MAC routes in control-plane using MP-BGP protocol. Control-plane MAC learning brings a number of benefits that allow EVPN to address the VPLS shortcomings, including support for multi-homing with per-flow load balancing.

In EVPN, PEs advertise the MAC addresses learned from the CEs that are connected to them, along with an MPLS label, to other PEs in the control plane using Multiprotocol BGP (MP-BGP). Control-plane learning enables load balancing of traffic to and from CEs that are multihomed to multiple PEs. This is in addition to load balancing across the MPLS core via multiple LSPs between the same pair of PEs. It also improves convergence times in the event of certain network failures.

Note: The EVPN will supported over static LSP, LDP,BGP-LU transports.

VPN Terminology

MAC-VRF: A virtual routing and forwarding table for storing MACs on a PE for specific bridge domain.

CE: Customer Edge device, e.g., a host, router, or switch.

PE: Provider edge device

EVI: An EVPN instance spanning the Provider Edge (PE) devices participating in that EVPN.

Note: Ethernet Segment (ES): Set of Ethernet links connected between CE and PE. Single CE can be connected to multiple PEs.

Ethernet Segment Identifier (ESI): A unique non-zero identifier that identifies an Ethernet segment is called an ESI

Ethernet Tag: An Ethernet tag identifies a particular broadcast domain, e.g., a VLAN. An EVPN instance consists of one or more broadcast domains.

Benefits

The EVPN control-plane MAC learning has the following benefits:

- Eliminate flood and learn mechanism as hosts are learned over control plane.
- OcNOS supports both dynamically learned hosts and statically configured hosts, which are advertised/learned over the EVPN control plane.
- Fast-reroute, resiliency, and faster convergence in case of multihoming
- Load balancing of traffic to and from CEs that are multihomed to multiple PE's.

The following EVPN types are supported:

- Single-homed CE: One CE is connected to One PE device.
- Multihomed CE: One CE is connected to Multiple PE devices. OcNOS supports dual-homed CEs with all- active multi homing mode.

Route Types

These EVPN route types are supported:

- Route Type 1: Ethernet Auto-Discovery (AD) Route

  The Ethernet (AD) routes are advertised on per EVI and per ESI basis. These routes are sent per ES. They carry the list of EVIs that belong to the ES.

  This route is advertised when multihomed CEs already exist.

- Route Type 2: MAC/IP Advertisement Route

  The host's IP and MAC addresses are advertised to the peers within NLRI. The control plane learning of MAC addresses reduces unknown unicast flooding.

- Route Type 3: Inclusive Multicast Ethernet Tag Route

  This route establishes the connection for broadcast, unknown unicast, and multicast (BUM) traffic from a source PE to a remote PE.

  This route is advertised on per VLAN and per ESI basis.

- Route Type 4: Ethernet Segment Route

  Ethernet segment routes enable to connect a CE device to two or PE devices.

  Ethernet segment routes enable the discovery of connected PE devices that are connected to the same Ethernet segment.

EVPN auto route target will be supported under MAC VRF.

In EVPN-VPWS the auto-discovery of peer PE nodes is done with the pair of Ethernet A-D routes. Inclusive Multicast route does not have participation on auto-discovery unlike ELAN-EVPN VPLS. Since there is no mac-advertisement, MAC-IP route is not applicable

Note: Only Sub-interface supported as Access-port for EVPN-MPLS.

EVPN MPLS Single Homing

Topology

Figure 1-1 depicts the Single Homed topology for the EVPN MPLS configuration examples for both ELINE and ELAN service with LDP as underlay MPLS path.

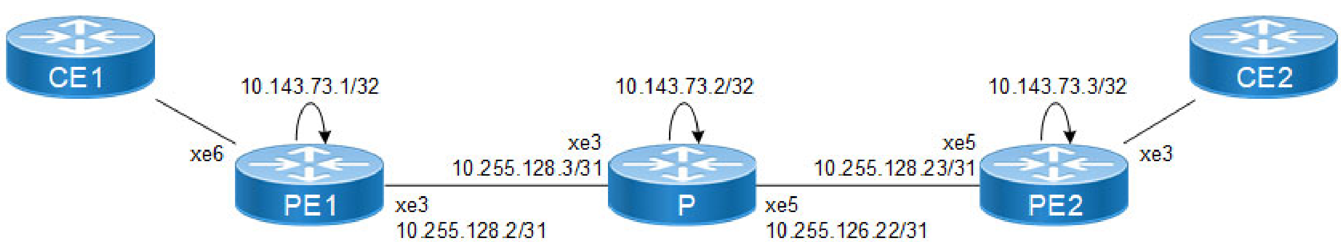

Figure 1-1: EVPN MPLS Single Homing configuration

PE1: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.1/32 secondary`	Configure IP address on loopback interface.
`(config-if)#commit`	Commit the transaction.
`(config-if)#exit`	Exit interface mode

PE1: Global EVPN MPLS Command

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS
`(config)#evpn mpls vtep-ip-global 10.143.73.1`	Configuring VTEP global IP to loopback IP
`(config)#commit`	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.

PE1: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 10.143.73.1`	Set the router ID to IP address 10.143.73.1
`(config-router)#transport-address ipv4 10.143.73.1`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 10.143.73.3`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config)#commit`	Commit the transaction.

PE1: Interface Configuration Network Side

`(config)#interface xe3`	Enter the Interface mode for eth2.
`(config-if)#ip address 10.255.128.8/31`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit the transaction.

Note: For RSVP Configuration refer RSVP-TE Configuration

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode

PE1: MAC VRF Configuration with Auto route target

(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001
(config-vrf)#route-target both evpn-auto-rt	Configuring import and export value as evpn-auto-rt. Route target will be derived automatically. Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

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PE1: EVPN and MAC VRF Mapping

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001	Configure the EVPN-VPLS identifier with identifier 1001
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#interface xe6.2 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 2	Map vpn-id 2 to interface xe6.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.1001 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 1001	Setting Encapsulation to dot1q with VLAN ID 1001 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1001	Map vpn-id 1001 to interface xe6.1001 (VPLS)
OcNOS(config-access-if)#commit	Commit candidate configuration to be running configuration

P: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.6/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.255.128.25	Set the router ID to IP address 10.255.128.25
(config-router)#transport-address ipv4 10.255.128.25	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

P: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.9/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.

(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
(config-router)#transport-address ipv4 10.143.73.3	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit router mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring VTEP global IP to loopback IP
(config)#commit	Commit the transaction.

Interface Configuration Network Side:

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-ID configurations
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

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PE2: BGP Configuration

`(config)#router bgp 65010`	Enter the Router BGP mode, ASN: 65010
`(config-router)#neighbor 10.143.73.1 remote-as 65010`	Configuring PE1 as iBGP neighbor using it's loopback IP
`(config-router)#neighbor 10.143.73.1 update-source lo`	Source of routing updates as loopback
`(config-router)#address-family l2vpn evpn`	Entering into address family mode as EVPN
`(config-router-af)#neighbor 10.143.73.1 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)#exit`	Exiting of Address family mode
`(config)#commit`	Commit the transaction.

PE2: MAC VRF Configuration

`(config)#mac vrf vrf2`	Enter VRF mode
`(config-vrf)#rd 10.143.73.3:2`	Configuring Route-Distinguisher value 10.143.73.3:2
`(config-vrf)#route-target both 2:2`	Configuring import and export value as 2:2 Support: route-target export route-target import
`(config-vrf)#exit`	Exiting VRF Mode

PE2: MAC VRF Configuration with Auto route target

`(config)#mac vrf vpls1001`	Enter VRF mode
`(config-vrf)#rd 10.143.73.1:1001`	Configuring Route-Distinguisher value 10.143.73.1:1001
`(config-vrf)#route-target both evpn-auto-rt`	Configuring import and export value as evpn-auto-rt. Route target will be derived automatically.
`(config-vrf)#exit`	Exiting VRF Mode
`(config)#commit`	Commit the transaction.

PE2: EVPN and VRF Mapping

`(config)#evpn mpls id 252 xconnect target-mpls-id 2`	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Mapping vrf "vrf2" to EVPN-ELINE identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.
`(config)#evpn mpls id 1001`	Configure the EVPN-ELAN identifier with identifier 1001
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001`	Mapping vrf "vpls1001" to EVPN-ELAN identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

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PE2: Access Port Configuration

`(config)#interface xe2`	Enter the Interface mode for xe2.
`(config-if)#description access-side-int`	Giving Interface Description
`(config-if)#interface xe2.2 switchport`	Creating L2 sub interface of physical interface xe2
`(config-if)#encapsulation dot1q 2`	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
`(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-access-if)#map vpn-id 2`	Map vpn-id 252 to interface xe2.2 (VPWS)
`(config-access-if)#exit`	Exiting out of access interface mode
`(config-if)#interface xe2.1001 switchport`	Creating L2 sub interface of physical interface xe2
`(config-if)#encapsulation dot1q 1001`	Setting Encapsulation to dot1q with VLAN ID 1001 Supported Encapsulation: dot1ad, dot1q, untagged, default
`(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-access-if)#map vpn-id 1001`	Map vpn-id 1001 to interface xe2.1001 (VPLS)
`(config)#commit`	Commit candidate configuration to be running configuration

Validation

PE1: E-LAN

```
PE1#sh mac vrf vpls1001
VRF vpls1001, FIB ID 4098
 Router ID is not set
Interfaces:
VRF vpls1001; default RD 10.143.73.3:1001
 Evpn Auto RT:100:1073742025
Import VPN route-target communities
 Evpn Auto RT:100:1073742025
No import route-map
No export route-map
VPNv4 label allocation mode: per-vrf
VPNv6 label allocation mode: per-vrf
import-vnid: 1001
export-vnid: 1001


PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination      Status        Up/Down       Update        evpn-id
=====================================================================================
10.143.73.1     10.143.73.3      Installed     00:01:03      00:01:03      1001

Total number of entries are 1

PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                          Local               Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
=====================================================================================================================
 10.143.73.3      Installed   1001      xe3           24320         640       17        640       17

Total number of entries are 1

PE1#show evpn mpls id 1001
EVPN-MPLS Information
=================
```

```
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                            VLAN DF-Status Src-Addr        Dst-Addr
_____________________________________________________________________________________________________________________________
___
1001     vpls1001     L2       NW   ----      ----                           ---- ----      10.143.73.1     10.143.73.3
1001     vpls1001     --       AC   xe6.1001  --- Single Homed Port ---      ---- ----      ----            ----

Total number of entries are 2


PE1#show evpn mpls mac-table
=============================================================================================================================
                                                    EVPN MPLS MAC Entries
=============================================================================================================================
VNID      Interface VlanId Inner-VlanId Mac-Addr      VTEP-Ip/ESI                 Type          Status     AccessPortDesc
_____________________________________________________________________________________________________________________________
1001       ----      ----   ----         00ff.2300.0000 10.143.73.3                 Dynamic Remote  -------    -------
1001       ----      ----   ----         0023.1001.0001 10.143.73.3                 Dynamic Remote  -------    -------
1001       xe6.1001  ----   ----         0045.1001.0001 10.143.73.1                 Dynamic Local   -------    -------
1001       xe6.1001  ----   ----         0071.1001.0001 10.143.73.1                 Dynamic Local   -------    -------
```

PE1: E-LINE or VPWS

```
PE1#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                           Remote       Connection-Details
================================ ============
=====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                 PE-IP          MTU   Type   NW-Status
================================ ============
=====================================================================================
2             ----         1500  252          xe6.2        --- Single Homed Port ---     10.143.73.3     1500  AC-NW  NW-SET

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
=======================================================================================================
10.143.73.1      10.143.73.3      Installed     00:01:10      00:01:10      2             252

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                    Local              Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
=====================================================================================================================
 10.143.73.3      Installed   2         252          xe3          24320          --         16       --         16

Total number of entries are 1

PE1#show evpn mpls xconnect id 2
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up
```

```
Local                            Remote       Connection-Details
================================ ============
===================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
===================================================================================
2            ----          1500  252          xe6.2        --- Single Homed Port ---     10.143.73.3     1500  AC-NW  NW-SET

Total number of entries are 1
```

PE2: ELAN

```
PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
===================================================================================
10.143.73.3      10.143.73.1      Installed     00:04:03      00:04:03      1001

Total number of entries are 1

PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                          Local             Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
=====================================================================================================================
 10.143.73.1      Installed   1001      xe5           24321         640       17        640       --

Total number of entries are 1

PE2#show evpn mpls id 1001
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN DF-Status Src-Addr        Dst-Addr
_____________________________________________________________________________________________________________________________
___
1001     vpls1001     L2       NW   ----      ----                           ---- ----      10.143.73.3      10.143.73.1
1001     vpls1001     --       AC   xe2.1001 --- Single Homed Port ---     ---- ----      ----             ----

Total number of entries are 2


PE2#show evpn mpls mac-table
=============================================================================================================================
==============
                                                     EVPN MPLS MAC Entries
=============================================================================================================================
==============
VNID      Interface VlanId Inner-VlanId Mac-Addr      VTEP-Ip/ESI                  Type          Status     AccessPortDesc
_____________________________________________________________________________________________________________________________
______________
1001       ----      ----   ----         0045.1001.0001 10.143.73.1                  Dynamic Remote  -------    -------
1001       ----      ----   ----         0071.1001.0001 10.143.73.1                  Dynamic Remote  -------    -------
1001       xe2.1001 ----   ----         00ff.2300.0000 10.143.73.3                  Dynamic Local   -------    -------
1001       xe2.1001 ----   ----         0023.1001.0001 10.143.73.3                  Dynamic Local   -------    -------
```

PE2: ELINE or VPWS

```
PE2#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
```

```
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP           MTU   Type   NW-Status
================================ ============
==================================================================================
252          ----          1500  2             xe2.2       --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
=============================================================================================================
10.143.73.3      10.143.73.1      Installed     00:04:10      00:04:10      252           2

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                         Local               Remote
 Destination       Status       VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
==============================================================================================================================
 10.143.73.1       Installed    252       2            xe5          24321         --        16        --        16

Total number of entries are 1

PE2#show evpn mpls xconnect id 252
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP           MTU   Type   NW-Status
================================ ============
==================================================================================
252          ----          1500  2             xe2.2       --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1
```

EVPN MPLS Single Homing Over BGP-LU

Topology

depicts the Single Homed topology for the EVPN MPLS configuration examples for both ELINE and ELAN service with BGP-LU as underlay MPLS path which in turn over another underlay of LDP/RSVP/SR MPLS paths.

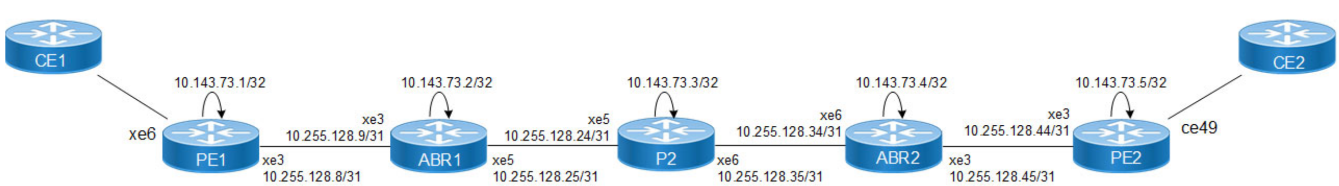

Figure 1-2: EVPN MPLS Single Homing over LU configuration

Configuration

PE1: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.1/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit candidate configuration to be running configuration

PE1: Global EVPN MPLS Command

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS
`(config)#evpn mpls vtep-ip-global 10.143.73.1`	Configuring VTEP global IP to loopback IP
`(config)#commit`	Commit candidate configuration to be running configuration

PE1: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 10.143.73.1`	Set the router ID to IP address 10.143.73.1
`(config-router)# transport-address ipv4 10.143.73.1`	Configure transport address at LDP mode
`(config-router)#targeted-peer ipv4 10.143.73.5`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config)#commit`	Commit candidate configuration to be running configuration

PE1: Interface Configuration Network Side

`(config)#interface xe3`	Enter the Interface mode for eth2.
`(config-if)#ip address 10.255.128.8/31`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config)#commit`	Commit candidate configuration to be running configuration

Note: For RSVP Configuration refer RSVP-TE Configuration.

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PE1: OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.2 remote-as 65010	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.2 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.1/32	Advertise 10.143.73.1/31 network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.2 activate	Activate the ipv4 labeled-unicast neighbor
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.5 activate	Enabling EVPN Address family for neighbor
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2 Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001

(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001 Support: route-target export Support: route-target export
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: EVPN and MAC VRF Mapping

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001	Configure the EVPN-VPLS identifier with identifier 1001
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe6.2 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 2	Map vpn-id 2 to interface xe6.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.1001 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 1001	Setting Encapsulation to dot1q with VLAN ID 1001 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1001	Map vpn-id 1001 to interface xe6.1001 (VPLS)
(config-access-if)#commit	Commit candidate configuration to be running configuration

ABR1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.2/32 secondary	Configure IP address on loopback interface.

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(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

ABR1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#transport-address ipv4 10.143.73.2	Configure transport address under router ldp
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

ABR1: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.9/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

ABR1: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 100	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.25/31 area 0.0.0.0	Advertise network address in OSPF.
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 1	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.9/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR1: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring ABR2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.2/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.4 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.1 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
(config)#commit	Commit candidate configuration to be running configuration

P2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-f)#commit	Commit the transaction.

P2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#commit	Commit the transaction.

P2: Interface Configuration

(config)#interface xe5	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.35/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#commit	Commit the transaction.

P2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#network 10.255.128.35/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.4/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the transaction.

ABR2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#transport-address ipv4 10.143.73.4	Configure transport address under router ldp
(config)#commit	Commit the transaction.

ABR2: Interface Configuration

(config)#interface xe6	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.34/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.45/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#commit	Commit the transaction.

ABR2: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.4	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.4/32 area 0.0.0.0 instance-id 200	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.34/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#network 10.255.128.45/31 area 0.0.0.0 instance-id 100	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.2 remote-as 65010	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.2 update-source lo	Source of routing updates as loopback

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(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.4/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.2 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.2 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.2 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.5 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
(config-router-af)#commit	Commit the transaction.

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.5/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.5	Set the router ID to IP address 10.143.73.5
(config-router)#transport-address ipv4 10.143.73.5	Configure transport address under router ldp
(config-router)#targeted-peer ipv4 10.143.73.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature

(config)#evpn mpls vtep-ip-global 10.143.73.5	Configuring VTEP global IP to loopback IP
(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.44/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-router)#commit	Commit the transaction.

PE2: OSPF Configuration

(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.5	Router-ID configurations
(config-router)#network 10.143.73.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.44/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring ABR2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.5/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE2: MAC VRF Configuration

`(config)#mac vrf vrf2`	Enter VRF mode
`(config-vrf)#rd 10.143.73.5:2`	Configuring Route-Distinguisher value 10.143.73.3:2
`(config-vrf)#route-target both 2:2`	Configuring import and export value as 2:2 Support: route-target export route-target import
`(config-vrf)#exit`	Exiting VRF Mode
`(config)#mac vrf vpls1001`	Enter VRF mode
`(config-vrf)#rd 10.143.73.5:1001`	Configuring Route-Distinguisher value 10.143.73.3:1001
`(config-vrf)#route-target both 1001:1001`	Configuring import and export value as 1001:1001
`(config-vrf)#commit`	Commit the transaction.

PE2: EVPN and VRF Mapping

`(config)#evpn mpls id 252 xconnect target-mpls-id 2`	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Mapping vrf "vrf2" to EVPN-ELINE identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.
`(config)#evpn mpls id 1001`	Configure the EVPN-ELAN identifier with identifier 1001
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001`	Mapping vrf "vpls1001" to EVPN-ELAN identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

`(config)#interface xe2`	Enter the Interface mode for xe2.
`(config-if)#description access-side-int`	Giving Interface Description
`(config-if)#interface xe2.2 switchport`	Creating L2 sub interface of physical interface xe2
`(config-if)#encapsulation dot1q 2`	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
`(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-access-if)#map vpn-id 252`	Map vpn-id 252 to interface xe2.2 (VPWS)
`(config-access-if)#exit`	Exiting out of access interface mode
`(config-if)#interface xe2.1001 switchport`	Creating L2 sub interface of physical interface xe2
`(config-if)#encapsulation dot1q 1001`	Setting Encapsulation to dot1q with VLAN ID 1001 Supported Encapsulation: dot1ad, dot1q, untagged, default
`(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-access-if)#map vpn-id 1001`	Map vpn-id 1001 to interface xe2.1001 (VPLS)
`(config)#commit`	Commit candidate configuration to be running configuration

Validation

PE1: E-LAN

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
10.143.73.1      10.143.73.5      Installed     00:01:03      00:01:03      1001

Total number of entries are 1

PE1#sh evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
 (*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+=========+===============+=========+=========+=========+=========+============+=========+======
======+========
                                                          Local            Remote            RSVP-Multipath         Underlay
 Destination    Status      VPN-ID    Policy         MC-Label  UC-Label  MC-Label  UC-Label  Grp-Name    NHLFE-ix  NW-Intf
NW-Label
================+===========+=========+===============+=========+=========+=========+=========+============+=========+======
======+========
 10.143.73.5    Installed   1001      --              640       17        640       --        --           --        xe3
24325

Total number of entries are 1

PE1#show evpn mpls id 1001
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                         VLAN DF-Status Src-Addr        Dst-Addr
_____________________________________________________________________________________________________________________________
___
1001     vpls1001     L2       NW   ----      ----                        ---- ----      10.143.73.1     10.143.73.5
1001     vpls1001     --       AC   xe6.1001  --- Single Homed Port ---   ---- ----      ----            ----

Total number of entries are 2


PE1#sh mpls forwarding-table | inc 10.143.73.5
   B>   10.143.73.5/32      6         10        -           -      LSP_DEFAULT  24960       xe3         No    10.143.73.2

PE1#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale
     Network          Next Hop        In Label     Out Label
*>  10.143.73.1/32   0.0.0.0          24320         -
*>i 10.143.73.2/32   10.143.73.2      24322        24961
*>i 10.143.73.4/32   10.143.73.2      24323        24963
*>i 10.143.73.5/32   10.143.73.2      24321        24960
PE1#

PE1#show evpn mpls mac-table
=============================================================================================================================
                                                     EVPN MPLS MAC Entries
=============================================================================================================================
VNID       Interface VlanId Inner-VlanId Mac-Addr       VTEP-Ip/ESI                  Type          Status     AccessPortDesc
_____________________________________________________________________________________________________________________________

1001       ----      ----   ----         00ff.2300.0000 10.143.73.5                    Dynamic Remote  -------    -------
1001       ----      ----   ----         0023.1001.0001 10.143.73.5                    Dynamic Remote  -------    -------
1001       xe6.1001  ----   ----         0045.1001.0001 10.143.73.1                    Dynamic Local   -------    -------
1001       xe6.1001  ----   ----         0071.1001.0001 10.143.73.1                    Dynamic Local   -------    -------
```

PE1: E-LINE or VPWS

```
PE1#show evpn mpls xconnect
```

```
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
=====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
=====================================================================================
2             ----         1500  252          xe6.2       --- Single Homed Port ---     10.143.73.5     1500  AC-NW  NW-SET

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
========================================================================================================
10.143.73.1      10.143.73.5      Installed     00:01:10      00:01:10      2             252

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
 (*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+=========+=========+===============+=========+=========+============+=========+============+===
======
                             Local     Remote                        Local     Remote       RSVP-Multipath         Underlay
 Destination     Status      VPWS-ID   VPWS-ID   Policy          UC-Label  UC-Label  Grp-Name     NHLFE-ix  NW-Intf      NW-
Label
================+===========+=========+=========+===============+=========+=========+============+=========+============+===
======
 10.143.73.5     Installed   2         252       --              16        16        --           --        xe3          24325

Total number of entries are 1

PE1#sh mpls forwarding-table | inc 10.143.73.5
   B>   10.143.73.5/32      6         10        -           -     LSP_DEFAULT  24960        xe3         No    10.143.73.2

PE1#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale
     Network          Next Hop        In Label     Out Label
*>  10.143.73.1/32   0.0.0.0           24320          -
*>i 10.143.73.2/32   10.143.73.2       24322        24961
*>i 10.143.73.4/32   10.143.73.2       24323        24963
*>i 10.143.73.5/32   10.143.73.2       24321        24960

PE1#show evpn mpls xconnect id 2
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
=====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
=====================================================================================
2            ----          1500  252          xe6.2       --- Single Homed Port ---     10.143.73.5     1500  AC-NW  NW-SET

Total number of entries are 1
```

PE2: ELAN

```
PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
==================================================================================
10.143.73.5      10.143.73.1      Installed     00:04:03      00:04:03      1001

Total number of entries are 1

PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
 (*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+=========+===============+=========+=========+=========+=========+============+=========+======
======+========
                                                          Local            Remote            RSVP-Multipath         Underlay
 Destination     Status     VPN-ID    Policy         MC-Label  UC-Label  MC-Label  UC-Label  Grp-Name     NHLFE-ix  NW-Intf
NW-Label
================+===========+=========+===============+=========+=========+=========+=========+============+=========+======
======+========
 10.143.73.1     Installed   1001      --             640       17        640       --        --           --        xe3
24321

Total number of entries are 1
PE2#
PE2#sh mpls forwarding-table | include 10.143.73.1/32
   B>   10.143.73.1/32      1         1         -           -     LSP_DEFAULT  24961        xe5         No    10.143.73.4

PE2#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale
     Network          Next Hop        In Label     Out Label
*>i 10.143.73.1/32   10.143.73.4       24321        24961
*>i 10.143.73.2/32   10.143.73.4       24323        24963
*>i 10.143.73.4/32   10.143.73.4       24322        24960
*>  10.143.73.5/32   0.0.0.0           24320          -

PE2#show evpn mpls id 1001
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN DF-Status Src-Addr         Dst-Addr
_____________________________________________________________________________________________________________________________
___
1001     vpls1001     L2       NW   ----      ----                          ---- ----      10.143.73.5      10.143.73.1
1001     vpls1001     --       AC   xe2.1001 --- Single Homed Port ---     ---- ----      ----             ----

Total number of entries are 2

PE2#show evpn mpls mac-table
=============================================================================================================================
==============
                                                     EVPN MPLS MAC Entries
=============================================================================================================================
==============
VNID      Interface VlanId Inner-VlanId Mac-Addr       VTEP-Ip/ESI                  Type           Status     AccessPortDesc
_____________________________________________________________________________________________________________________________
______________
1001       ----      ----   ----         0045.1001.0001 10.143.73.1                  Dynamic Remote  -------    -------
1001       ----      ----   ----         0071.1001.0001 10.143.73.1                  Dynamic Remote  -------    -------
1001       xe2.1001 ----   ----         00ff.2300.0000 10.143.73.5                  Dynamic Local   -------    -------
1001       xe2.1001 ----   ----         0023.1001.0001 10.143.73.5                  Dynamic Local   -------    -------
```

PE2: ELINE or VPWS

```
PE2#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
```

```
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
====================================================================================
252           ----         1500  2            xe2.2       --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
==========================================================================================================
10.143.73.5      10.143.73.1      Installed     00:04:10      00:04:10      252           2

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                      Local              Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
==============================================================================================================================
 10.143.73.1      Installed   252       2           xe5          24321          --        16       --        16

Total number of entries are 1

PE2#sh mpls forwarding-table | include 10.143.73.1/32
   B>   10.143.73.1/32      1         1        -           -     LSP_DEFAULT  24961        xe5         No    10.143.73.4

PE2#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale
     Network          Next Hop        In Label     Out Label
*>i 10.143.73.1/32   10.143.73.4       24321        24961
*>i 10.143.73.2/32   10.143.73.4       24323        24963
*>i 10.143.73.4/32   10.143.73.4       24322        24960
*>  10.143.73.5/32   0.0.0.0           24320          -

PE2#show evpn mpls xconnect id 252
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
====================================================================================
252           ----         1500  2            xe2.2       --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1
```

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EVPN MPLS Multihoming

Topology

The diagram depicts the Multi Homed topology for the EVPN MPLS configuration examples that follow.

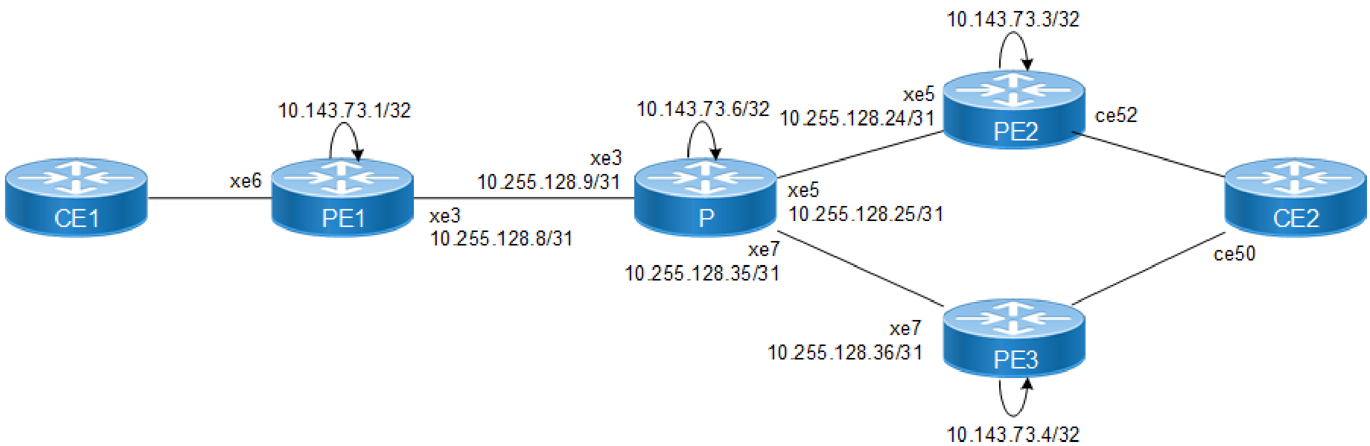

Figure 1-3: MPLS EVPN multi-homing configuration

PE1: Loopback Interface

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.1/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode
`(config-if)#commit`	Commit the transaction.

PE1: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 10.143.73.1`	Set the router ID to IP address 10.143.73.1
`(config-router)#transport-address ipv4 10.143.73.1`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 10.143.73.3`	Configure targeted peer.
`(config-router)#targeted-peer ipv4 10.143.73.4`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config-router)#commit`	Commit the transaction.

PE1: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.1	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.8/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#commit	Commit the transaction.

Note: For RSVP Configuration refer RSVP-TE Configuration

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN

(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.4 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1700	Configuring Route-Distinguisher value 10.143.73.1:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with source identifier 1700 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#interface xe6.1700 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#description access-side-int	Giving Interface Description
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1700	Map vpn-id 1700 to interface xe6.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.300 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000

`(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-access-if)#map vpn-id 3000`	Map vpn-id 3000 to interface xe6.3000 (VPLS)
`(config-access-if)#commit`	Commit candidate configuration to be running configuration

P: Loopback Interface

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.6/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode
`(config-if)#commit`	Commit the transaction.

P: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 10.143.73.6`	Set the router ID to IP address 10.143.73.6
`(config-router)#transport-address ipv4 10.143.73.6`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config-router)#commit`	Commit the transaction.

P: Interface Configuration

`(config)#interface xe3`	Enter the Interface mode for xe3.
`(config-if)#ip address 10.255.128.9/31`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe5`	Enter the Interface mode for xe5
`(config-if)#ip address 10.255.128.25/31`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#exit`	Exit interface mode
`(config)#interface po92`	Enter the Interface mode for po92
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#interface xe7`	Enter the Interface mode for xe7
`(config-if)#channel-group 92 mode active`	Moving interface to Dynamic LAG 92
`(config-if)#interface xe8`	Enter the Interface mode for xe8
`(config-if)#channel-group 92 mode active`	Moving interface to Dynamic LAG 92

(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.6/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.8/31 area 0.0.0.0	Advertise xe3 network address in OSPF that comes under same subnet
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#network 10.255.128.36/31 area 0.0.0.0	Advertise po92 network address in OSPF that comes under same subnet
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
OcNOS(config)#commit	Commit candidate configuration to be running configuration

PE2: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
(config-router)#transport-address ipv4 10.143.73.3	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note:It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.4	Configure targeted peer
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#evpn esi hold-time 60	Delay timer for ESI to come up before enabling evpn
(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#commit	Commit the transaction.

Note: For RSVP Configuration refer RSVP-TE Configuration

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-ID configurations
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
OcNOS(config)#commit	Commit candidate configuration to be running configuration

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback

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(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.4 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.3:1700	Configuring Route-Distinguisher value 10.143.73.3:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700 Support: route-target export route-target import
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.3:1001	Configuring Route-Distinguisher value 10.143.73.3:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE2: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1700
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default

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(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1800	Map vpn-id 2 to interface xe2.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.300 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface xe2	Enter the Interface mode for xe2
(config-if)#channel-group 90 mode active	Putting interface xe2 in Dynamic LAG po90
(config)#commit	Commit candidate configuration to be running configuration

PE3: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

PE3: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.4	Set the router ID to IP address 10.143.73.4
(config-router)#transport-address ipv4 10.143.73.4	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.3	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router LDP mode
(config-router)#commit	Commit the transaction.

PE3: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.4	Configuring VTEP global IP to loopback IP

(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#evpn esi hold-time 60	Delay timer for ESI to come up before enabling evpn
(config)#commit	Commit the transaction.

PE3: Interface Configuration Network Side

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.36/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#interface xe7	Enter the Interface mode for xe7
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#interface xe8	Enter the Interface mode for xe8
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

Note: For RSVP Configuration refer RSVP-TE Configuration

PE3: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.4	Router-ID configurations
(config-router)#network 10.143.73.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.36/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

PE3: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN

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(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE3: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.4:1700	Configuring Route-Distinguisher value 10.143.73.4:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.4:1001	Configuring Route-Distinguisher value 10.143.73.4:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE3: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration

(config-access-if)#map vpn-id 1800	Map vpn-id 1800 to Dynamic LAG sub interface po90.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.3000 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface xe2	Enter the Interface mode for xe2
(config-if)#channel-group 90 mode active	Putting interface xe2 in Dynamic LAG po90
(config-if)#commit	Commit candidate configuration to be running configuration

Validation

PE1: ELAN

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
10.143.73.1      10.143.73.4      Installed     00:13:32      00:13:32      3000
10.143.73.1      10.143.73.3      Installed     00:13:33      00:13:33      3000

Total number of entries are 2

PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                          Local               Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
===================================================================================================================
 10.143.73.4      Installed   3000      xe3          25601         753       403       654       53
 10.143.73.3      Installed   3000      xe3          25600         753       403       753       402

Total number of entries are 2

PE1#show evpn mpls id 3000
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN DF-Status Src-Addr        Dst-Addr
_____________________________________________________________________________________________________________________________
___
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.1      10.143.73.4
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.1      10.143.73.3
3000     ----         --       AC   xe6.300   --- Single Homed Port ---     ---- ----      ----             ----

PE1#show evpn mpls mac-table
==============================================================================================================================
                                                     EVPN MPLS MAC Entries
==============================================================================================================================
VNID       Interface VlanId Inner-VlanId Mac-Addr       VTEP-Ip/ESI                  Type          Status     AccessPortDesc
______________________________________________________________________________________________________________________________
______________
3000       xe6.300   ----   ----         0211.2000.03e8 10.143.73.1                  Dynamic Local   -------    -------
3000       xe6.300   ----   ----         b86a.97cd.6a3d 10.143.73.1                  Dynamic Local   -------    -------
3000       ----      ----   ----         0224.2000.03e8 00:00:00:aa:aa:bb:bc:00:00:00 Dynamic Remote  -------    -------
3000       ----      ----   ----         b86a.97d2.53bb 00:00:00:aa:aa:bb:bc:00:00:00 Dynamic Remote  -------    -------
```

PE1: ELINE or VPWS

```
PE1#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
==================================================================================
1700         ----          1500  1800         xe6.1700     00:00:00:aa:aa:bb:bc:00:00:00 10.143.73.4     1500  AC-NW  NW-SET

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
================================================================================================
10.143.73.1      10.143.73.4      Installed     00:16:50      00:16:50      1700         1800
10.143.73.1      10.143.73.3      Installed     00:16:50      00:16:50      1700         1800

Total number of entries are 2

PE1#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                    Local             Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
==============================================================================================================================
==
 10.143.73.4      Installed   1700     1800          xe3          25601         --        402       --        52
 10.143.73.3      Installed   1700     1800          xe3          25600         --        402       --        401

Total number of entries are 2

PE1#show evpn mpls xconnect id 1700
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
==================================================================================
1700         ----          1500  1800         xe6.1700     00:00:00:aa:aa:bb:bc:00:00:00 10.143.73.3     1500  AC-NW  NW-SET
                                                                                         10.143.73.4     1500  ----   ----
Total number of entries are 1
```

PE2: VPLS

```
PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
==================================================================================
10.143.73.3      10.143.73.4      Installed     00:24:41      00:24:41      3000
10.143.73.3      10.143.73.1      Installed     00:24:38      00:24:38      3000

Total number of entries are 2
```

```
PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                                  Local              Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
==================================================================================================================
 10.143.73.4      Installed   3000      xe5           24965         753       402       654       53
 10.143.73.1      Installed   3000      xe5           25604         753       402       753       403

Total number of entries are 2

PE2#show evpn mpls id 3000
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN DF-Status Src-Addr        Dst-Addr
_____________________________________________________________________________________________________________________________
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.3      10.143.73.4
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.3      10.143.73.1
3000     ----         --       AC   po90.300  00:00:00:aa:aa:bb:bc:00:00:00 ---- DF        ----             ----

Total number of entries are 3

PE2#show evpn mpls mac-table
=============================================================================================================================
                                                    EVPN MPLS MAC Entries
=============================================================================================================================
VNID       Interface VlanId Inner-VlanId Mac-Addr       VTEP-Ip/ESI                  Type          Status     AccessPortDesc
_____________________________________________________________________________________________________________________________
3000       ----      ----   ----         0211.2000.03e8 10.143.73.1                    Dynamic Remote  -------    -------
3000       ----      ----   ----         b86a.97cd.6a3d 10.143.73.1                    Dynamic Remote  -------    -------
3000       ----      ----   ----         0224.2000.03e8 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Remote  -------    -------
3000       po90.300  ----   ----         b86a.97d2.53bb 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Local   -------    -------
```

PE2: VPWS

```
PE2#show evpn mpls xconnect id 1800
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
==================================================================================
1800         ----          1500  1700         po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
======================================================================================
10.143.73.3      10.143.73.1      Installed     00:50:18      00:50:18      1800         1700

Total number of entries are 1


PE2#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
```

```
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
================================================================================
1800         ----          1500  1700         po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                         Local              Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
==============================================================================================================================
 10.143.73.1      Installed   1800     1700          xe5          25604         --        401       --        402

Total number of entries are 1
```

PE3: VPLS

```
PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
================================================================================
10.143.73.4      10.143.73.3      Installed     00:22:11      00:22:11      3000
10.143.73.4      10.143.73.1      Installed     00:22:11      00:22:11      3000

Total number of entries are 2

PE3#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                        Local              Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
============================================================================================================
 10.143.73.3      Installed   3000      po92           24962         654       53         753       402
 10.143.73.1      Installed   3000      po92           24964         654       53         753       403

Total number of entries are 2

PE3#show evpn mpls id 3000
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                            VLAN DF-Status Src-Addr         Dst-Addr
_____________________________________________________________________________________________________________________________
___
3000     ----         L2       NW   ----      ----                           ---- ----      10.143.73.4      10.143.73.3
3000     ----         L2       NW   ----      ----                           ---- ----      10.143.73.4      10.143.73.1
3000     ----         --       AC   po90.300  00:00:00:aa:aa:bb:bc:00:00:00 ---- NON-DF    ----             ----

Total number of entries are 3

PE3#show evpn mpls mac-table
==============================================================================================================================
                                                    EVPN MPLS MAC Entries
==============================================================================================================================
VNID      Interface VlanId Inner-VlanId Mac-Addr      VTEP-Ip/ESI                  Type          Status     AccessPortDesc
_____________________________________________________________________________________________________________________________
______________

3000       ----      ----   ----         0211.2000.03e8 10.143.73.1                  Dynamic Remote  -------    -------
```

```
3000      ----     ----   ----        b86a.97cd.6a3d 10.143.73.1                  Dynamic Remote  -------    -------
3000      ----     ----   ----        0224.2000.03e8 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Remote  -------    -------
3000      po90.300 ----   ----        b86a.97d2.53bb 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Local   -------    -------
```

PE3: VPWS

```
PE3#show evpn mpls xconnect id 1800
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
=====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
=====================================================================================
1800         ----          1500  1700         po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
=============================================================================================================
10.143.73.4      10.143.73.1      Installed     00:23:18      00:23:18      1800         1700

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                      Local              Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
=================================================================================================================================
==
 10.143.73.1      Installed   1800     1700          po92           24964         --        52        --        402

Total number of entries are 1

PE3#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
=====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
=====================================================================================
1800         ----          1500  1700         po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1
```

EVPN MPLS Multhoming over BGP-LU

Topology

The diagram depicts the Multi Homed topology for the EVPN MPLS configuration and examples for both ELINE and ELAN service with BGP-LU as underlay MPLS path.

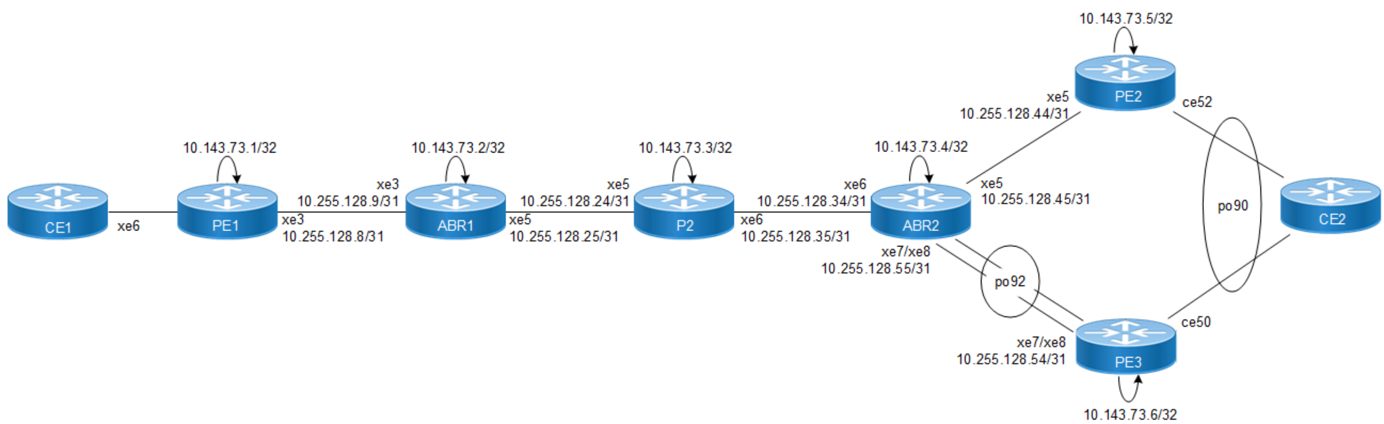

Figure 1-4: MPLS EVPN multi-homing over LU configuration

Configuration

PE1: Loopback Interface

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.1/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit the transaction.

PE1: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 10.143.73.1`	Set the router ID to IP address 10.143.73.1
`(config-router)#transport-address ipv4 10.143.73.1`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.6`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config)#commit`	Commit the transaction.

PE1: Global EVPN MPLS Command

`(config)#evpn mpls enable`	Enable EVPN MPLS
`(config)#commit`	Commit candidate configuration to be running configuration
`(config)#evpn mpls vtep-ip-global 10.143.73.1`	Configuring VTEP global IP to loopback IP
`(config)#hardware-profile filter evpn-mpls-mh enable`	Enable hardware-profile filter EVPN-MPLS-MH
`(config)#evpn mpls multihoming enable`	Enable Multihoming
`(config)#commit`	Commit the transaction.

PE1: Interface Configuration Network Side

`(config)#interface xe3`	Enter the Interface mode for xe3.
`(config-if)#ip address 10.255.128.8/31`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#exit`	Exit interface mode

Note: For RSVP Configuration refer RSVP-TE Configuration.

PE1: OSPF Configuration

`(config)#router ospf 100`	Enter the Router OSPF mode.
`(config-router)#ospf router-id 10.143.73.1`	Router-ID configurations
`(config-router)#network 10.143.73.1/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`(config-router)#network 10.255.128.8/31 area 0.0.0.0`	Advertise network address in OSPF.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.
`(config)#commit`	Commit the transaction.

PE1: BGP Configuration

`(config)#router bgp 65010`	Enter the Router BGP mode, ASN: 65010
`(config-router)#neighbor 10.143.73.5 remote-as 65010`	Configuring Neighbor as iBGP neighbor
`(config-router)#neighbor 10.143.73.5 update-source lo`	Source of routing updates as loopback
`(config-router)#neighbor 10.143.73.6 remote-as 65010`	Configuring Neighbor as iBGP neighbor
`(config-router)#neighbor 10.143.73.6 update-source lo`	Source of routing updates as loopback
`(config-router)#address-family l2vpn evpn`	Entering into address family mode as EVPN
`(config-router-af)#neighbor 10.143.73.5 activate`	Enabling EVPN Address family for neighbor

(config-router-af)#neighbor 10.143.73.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit the transaction.

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1700	Configuring Route-Distinguisher value 10.143.73.1:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.1:1001	Configuring Route-Distinguisher value 10.143.73.1:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with source identifier 1700 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#interface xe6.1700 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#description access-side-int	Giving Interface Description
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1700	Map vpn-id 1700 to interface xe6.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface xe6.300 switchport	Creating L2 sub interface of physical interface xe6
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default

(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface xe6.3000 (VPLS)
(config-access-if)#commit	Commit candidate configuration to be running configuration

ABR1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.2/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

ABR1: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.2	Set the router ID to IP address 10.143.73.2
(config-router)#transport-address ipv4 10.143.73.2	Configure transport address under router ldp
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

ABR1: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.9/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

ABR1: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 200	Advertise loopback address in OSPF.

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(config-router)#network 10.255.128.25/31 area 0.0.0.0	Advertise network address in OSPF.
(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.2/32 area 0.0.0.0 instance-id 100	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.9/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR1: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring ABR2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.2/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.4 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.1 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.1 next-hop-self	Configure next-hopself for the ipv4 labeled-unicast neighbor
(config-router-af)#commit	Commit the transaction.

P2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.

(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
(config-router)#transport-address ipv4 10.143.73.3	Configure transport address under router LDP
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

P2: Interface Configuration

(config)#interface xe5	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.35/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

P2: OSPF Configuration

(config)#router ospf 200	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#network 10.255.128.35/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.

(config-if)#ip address 10.143.73.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

ABR2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.4	Set the router ID to IP address 10.143.73.4
(config-router)#transport-address ipv4 10.143.73.4	Configure transport address under router ldp
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

ABR2: Interface Configuration

(config)#interface xe6	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.34/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.45/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface po92	Enter the Interface mode for po92
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#ip address 10.255.128.55/31	Configure IP address on the interface.
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#interface xe7	Enter the Interface mode for xe7
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#interface xe8	Enter the Interface mode for xe8
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#commit	Commit the transaction.

ABR2: OSPF Configuration

(config)#enable ext-ospf-multi-inst	Enable multiple-instance capabilit
(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.4	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.4/32 area 0.0.0.0 instance-id 300	Advertise loopback address in OSPF.

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(config-router)#network 10.255.128.34/31 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config)#router ospf 300	Enter the Router OSPF mode.
(config-router)#network 10.143.73.4/32 area 0.0.0.0 instance-id 200	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.45/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#network 10.255.128.55/31 area 0.0.0.0	Advertise po network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

ABR2: BGP-LU Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config)#allocate-label all	Configure allocate all under router bgp
(config-router)#neighbor 10.143.73.2 remote-as 65010	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.6 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.2 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.6 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Entering into address family ipv4 unicast
(config-router-af)# network 10.143.73.4/32	Advertise the network
(config-router-af)# exit-address-family	Exit from ipv4 address family
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.2 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.2 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.2 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 activate	Activate the ipv4 labeled-unicast neighbor
config-router-af)#neighbor 10.143.73.5 route-reflector-client	Configure neighbor as route reflector client
(config-router-af)#neighbor 10.143.73.5 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.6 activate	Activate the ipv4 labeled-unicast neighbor

`config-router-af)#neighbor 10.143.73.6 route-reflector-client`	Configure neighbor as route reflector client
`(config-router-af)#neighbor 10.143.73.6 next-hop-self`	Configure next-hop-self for the ipv4 labeled-unicast neighbor
`(config-router-af)#commit`	Commit candidate configuration to be running configuration

PE2: Loopback Interface

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.5/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit candidate configuration to be running configuration

PE2: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 10.143.73.5`	Set the router ID to IP address 10.143.73.5
`(config-router)#transport-address ipv4 10.143.73.5`	Configure transport address under router ldp
`(config-router)#targeted-peer ipv4 10.143.73.1`	Configure targeted peer.
`(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.6`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config)#commit`	Commit candidate configuration to be running configuration

PE2: Global EVPN MPLS Command

`(config)#evpn mpls enable`	Enable EVPN MPLS Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
`(config)#commit`	Commit candidate configuration to be running configuration
`(config)#evpn mpls vtep-ip-global 10.143.73.5`	Configuring VTEP global IP to loopback IP
`(config)#hardware-profile filter evpn-mpls-mh enable`	Enable hardware-profile filter EVPN-MPLS-MH
`(config)#evpn mpls multihoming enable`	Enable Multihoming
`(config)#evpn esi hold-time 60`	Delay timer for ESI to come up before enabling evpn
`(config)#commit`	Commit candidate configuration to be running configuration

PE2: Interface Configuration Network Side

(config)#interface xe5	Enter the Interface mode for xe5.
(config-if)#ip address 10.255.128.44/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

Note: For RSVP Configuration refer RSVP-TE Configuration.

PE2: OSPF Configuration

(config)#router ospf 300	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.5	Router-ID configurations
(config-router)#network 10.143.73.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.44/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.6 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.6 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor
(config-router-af)#exit-address-family	Exit the address family
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor

(config-router-af)#neighbor 10.143.73.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.5:1700	Configuring Route-Distinguisher value 10.143.75.3:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.5:1001	Configuring Route-Distinguisher value 10.143.73.5:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1700
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1800	Map vpn-id 2 to interface ce49.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90

(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.300 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface ce52	Enter the Interface mode for ce52
(config-if)#channel-group 90 mode active	Putting interface ce50 in Dynamic LAG po90
(config)#commit	Commit candidate configuration to be running configuration

PE3: Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.6/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.6	Set the router ID to IP address 10.143.73.5
(config-router)#transport-address ipv4 10.143.73.6	Configure transport address under router ldp
(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router-targeted-peer)# targeted-peer ipv4 10.143.73.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit from router LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration
(config)#evpn mpls vtep-ip-global 10.143.73.6	Configuring VTEP global IP to loopback IP
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter EVPN-MPLS-MH
(config)#evpn mpls multihoming enable	Enable Multihoming
(config)#evpn esi hold-time 60	Delay timer for ESI to come up before enabling evpn
(config)#commit	Commit candidate configuration to be running configuration

PE3: Interface Configuration Network Side

(config)#interface po92	Enter the Interface mode for xe3.
(config-if)#ip address 10.255.128.54/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config-if)#interface xe7	Enter the Interface mode for xe7
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#interface xe8	Enter the Interface mode for xe8
(config-if)#channel-group 92 mode active	Moving interface to Dynamic LAG 92
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: OSPF Configuration

(config)#router ospf 300	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Router-ID configurations
(config-router)#network 10.143.73.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.54/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE3: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.4 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.4 update-source lo	Source of routing updates as loopback
(config-router)#neighbor 10.143.73.5 remote-as 65010	Configuring Neighbor as iBGP neighbor
(config-router)#neighbor 10.143.73.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 labeled-unicast	Entering into address family ipv4 labeled-unicast
(config-router-af)#neighbor 10.143.73.4 activate	Activate the ipv4 labeled-unicast neighbor
(config-router-af)#neighbor 10.143.73.4 next-hop-self	Configure next-hop-self for the ipv4 labeled-unicast neighbor

(config-router-af)#exit-address-family	Exit the address family
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#neighbor 10.143.73.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE3: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.6:1700	Configuring Route-Distinguisher value 10.143.73.6:1700
(config-vrf)#route-target both 1700:1700	Configuring import and export value as 1700:1700
(config-vrf)#exit	Exiting VRF Mode
(config)#mac vrf vpls1001	Enter VRF mode
(config-vrf)#rd 10.143.73.6:1001	Configuring Route-Distinguisher value 10.143.73.6:1001
(config-vrf)#route-target both 1001:1001	Configuring import and export value as 1001:1001
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE3: EVPN and MAC VRF Mapping

(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1800
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "test" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier with identifier 3000
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration

(config)#interface po90	Enter the Interface mode for po90.
(config-if)#load-interval 30	Load interval setting
(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure ESI on a link on which Multi homed CE is connected
(config-if)#interface po90.1700 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 1700	Setting Encapsulation to dot1q with VLAN ID 1700 Supported Encapsulation: dot1ad, dot1q, untagged, default

(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 1800	Map vpn-id 1800 to Dynamic LAG sub interface po90.1700 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#interface po90.300 switchport	Creating L2 sub interface of Dynamic LAG po90
(config-if)#encapsulation dot1q 3000	Setting Encapsulation to dot1q with VLAN ID 3000 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 3000	Map vpn-id 3000 to interface po90.3000 (VPLS)
(config-access-if)#exit	Exiting out of Access if mode
(config-if)#interface ce50	Enter the Interface mode for ce50
(config-if)#channel-group 90 mode active	Putting interface ce50 in Dynamic LAG po90
(config)#commit	Commit candidate configuration to be running configuration

Validation

PE1: ELAN

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
10.143.73.1      10.143.73.5      Installed     00:13:32      00:13:32      3000
10.143.73.1      10.143.73.6      Installed     00:13:33      00:13:33      3000

Total number of entries are 2

PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                          Local               Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
==================================================================================================================
 10.143.73.5      Installed   3000      xe3          25601         753       403       654       53
 10.143.73.6      Installed   3000      xe3          25600         753       403       753       402

Total number of entries are 2

PE1#sh mpls forwarding-table | inc 10.143.73.5
   B>   10.143.73.5/32      6         10        -           -     LSP_DEFAULT  25601        xe3         No    10.143.73.2

PE1#sh mpls forwarding-table | inc 10.143.73.6
   B>   10.143.73.6/32      6         10        -           -     LSP_DEFAULT  25660        xe3         No    10.143.73.2

PE1#sh ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal, S - stale
     Network          Next Hop        In Label     Out Label
*>  10.143.73.1/32   0.0.0.0          24320         -
*>i 10.143.73.2/32   10.143.73.2      24322        25603
*>i 10.143.73.4/32   10.143.73.2      24323        25602
*>i 10.143.73.5/32   10.143.73.2      24321        25601
*>i 10.143.73.6/32   10.143.73.2      24324        25600

PE1#show evpn mpls id 3000
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN DF-Status Src-Addr         Dst-Addr
```

```
________________________________________________________________________________________________________________________________
___
3000     ----         L2      NW   ----      ----                          ---- ----      10.143.73.1      10.143.73.5
3000     ----         L2      NW   ----      ----                          ---- ----      10.143.73.1      10.143.73.6
3000     ----         --      AC   xe6.300   --- Single Homed Port ---     ---- ----      ----             ----

PE1#show evpn mpls mac-table
================================================================================================================================
                                                    EVPN MPLS MAC Entries
================================================================================================================================
VNID      Interface VlanId Inner-VlanId Mac-Addr       VTEP-Ip/ESI                   Type          Status     AccessPortDesc
________________________________________________________________________________________________________________________________
______________
3000      xe6.300   ----   ----         0211.2000.03e8 10.143.73.1                   Dynamic Local   -------    -------
3000      xe6.300   ----   ----         b86a.97cd.6a3d 10.143.73.1                   Dynamic Local   -------    -------
3000      ----      ----   ----         0224.2000.03e8 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Remote  -------    -------
3000      ----      ----   ----         b86a.97d2.53bb 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Remote  -------    -------
```

PE1: ELINE or VPWS

```
PE1#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
=====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
=====================================================================================
1700         ----          1500  1800         xe6.1700     00:00:00:aa:aa:bb:bc:00:00:00 10.143.73.5     1500  AC-NW  NW-SET

Total number of entries are 1

PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
==================================================================================================
10.143.73.1      10.143.73.5      Installed     00:16:50      00:16:50      1700         1800
10.143.73.1      10.143.73.6      Installed     00:16:50      00:16:50      1700         1800

Total number of entries are 2

PE1#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                        Local             Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
================================================================================================================================
==
 10.143.73.5      Installed   1700      1800         xe3          25601         --        402       --        52
 10.143.73.6      Installed   1700      1800         xe3          25600         --        402       --        401

Total number of entries are 2

PE1#show evpn mpls xconnect id 1700
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
```

```
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
==================================================================================
1700         ----          1500  1800         xe6.1700     00:00:00:aa:aa:bb:bc:00:00:00 10.143.73.5     1500  AC-NW  NW-SET
                                                                                          10.143.73.6     1500  ----   ----
Total number of entries are 1
```

PE2: VPLS

```
PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source            Destination       Status        Up/Down       Update        evpn-id
==================================================================================
10.143.73.5       10.143.73.6       Installed     00:24:41      00:24:41      3000
10.143.73.5       10.143.73.1       Installed     00:24:38      00:24:38      3000

Total number of entries are 2

PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                          Local              Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
============================================================================================================
 10.143.73.6      Installed   3000      xe5           24965         753       402       654       53
 10.143.73.1      Installed   3000      xe5           25604         753       402       753       403

Total number of entries are 2

PE2#show evpn mpls id 3000
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN DF-Status Src-Addr         Dst-Addr
________________________________________________________________________________________________________________________________
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.5      10.143.73.6
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.5      10.143.73.1
3000     ----         --       AC   po90.300  00:00:00:aa:aa:bb:bc:00:00:00 ---- DF        ----             ----

Total number of entries are 3

PE2#show evpn mpls mac-table
================================================================================================================================
                                                     EVPN MPLS MAC Entries
================================================================================================================================
VNID       Interface VlanId Inner-VlanId Mac-Addr       VTEP-Ip/ESI                   Type           Status     AccessPortDesc
________________________________________________________________________________________________________________________________
3000       ----      ----   ----         0211.2000.03e8 10.143.73.1                   Dynamic Remote -------    -------
3000       ----      ----   ----         b86a.97cd.6a3d 10.143.73.1                   Dynamic Remote -------    -------
3000       ----      ----   ----         0224.2000.03e8 00:00:00:aa:aa:bb:bc:00:00:00 Dynamic Remote -------    -------
3000       po90.300  ----   ----         b86a.97d2.53bb 00:00:00:aa:aa:bb:bc:00:00:00 Dynamic Local  -------    -------
```

PE2: VPWS

```
PE2#show evpn mpls xconnect id 1800
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
```

```
================================ ============
==================================================================================
VPN-ID      EVI-Name     MTU   VPN-ID      Source      Destination                 PE-IP          MTU   Type   NW-Status
================================ ============
==================================================================================
1800        ----         1500  1700        po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1


PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
=======================================================================================
10.143.73.5      10.143.73.1      Installed     00:50:18      00:50:18      1800         1700

Total number of entries are 1


PE2#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
==================================================================================
VPN-ID      EVI-Name     MTU   VPN-ID      Source      Destination                 PE-IP          MTU   Type   NW-Status
================================ ============
==================================================================================
1800        ----         1500  1700        po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                       Local             Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
=============================================================================================================================
 10.143.73.1      Installed   1800     1700          xe5          25604         --        401       --        402

Total number of entries are 1
```

PE3: VPLS:

```
PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
================================================================================
10.143.73.6      10.143.73.5      Installed     00:22:11      00:22:11      3000
10.143.73.6      10.143.73.1      Installed     00:22:11      00:22:11      3000

Total number of entries are 2

PE3#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
                                                                          Local             Remote
 Destination      Status      evpn-id   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
=============================================================================================================
 10.143.73.5      Installed   3000      po92           24962         654       53        753       402
 10.143.73.1      Installed   3000      po92           24964         654       53        753       403

Total number of entries are 2

PE3#show evpn mpls id 3000
EVPN-MPLS Information
=================
```

```
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN DF-Status Src-Addr        Dst-Addr
_____________________________________________________________________________________________________________________________
___
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.5     10.143.73.6
3000     ----         L2       NW   ----      ----                          ---- ----      10.143.73.5     10.143.73.1
3000     ----         --       AC   po90.300  00:00:00:aa:aa:bb:bc:00:00:00 ---- NON-DF    ----            ----

Total number of entries are 3

PE3#show evpn mpls mac-table
==============================================================================================================================
                                                    EVPN MPLS MAC Entries
==============================================================================================================================
VNID      Interface VlanId Inner-VlanId Mac-Addr      VTEP-Ip/ESI                  Type          Status     AccessPortDesc
_____________________________________________________________________________________________________________________________
______________

3000      ----      ----   ----        0211.2000.03e8 10.143.73.1                   Dynamic Remote  -------    -------
3000      ----      ----   ----        b86a.97cd.6a3d 10.143.73.1                   Dynamic Remote  -------    -------
3000      ----      ----   ----        0224.2000.03e8 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Remote  -------    -------
3000      po90.300  ----   ----        b86a.97d2.53bb 00:00:00:aa:aa:bb:bc:00:00:00  Dynamic Local   -------    -------
```

PE3: VPWS

```
PE3#show evpn mpls xconnect id 1800
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                           Remote       Connection-Details
================================ ============ 
=====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============ 
=====================================================================================
1800         ----          1500  1700         po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
=========================================================================================================
10.143.73.6      10.143.73.1      Installed     00:23:18      00:23:18      1800         1700

Total number of entries are 1

PE3#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
                              Local     Remote                                      Local              Remote
 Destination      Status      VPWS-ID   VPWS-ID   Network-Intf  Tunnel-Label  MC-Label  UC-Label  MC-Label  UC-Label
==============================================================================================================================
==
 10.143.73.1      Installed   1800     1700          po92           24964         --        52        --        402

Total number of entries are 1

PE3#show evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
```

```
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
====================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                 PE-IP          MTU   Type   NW-Status
================================ ============
====================================================================================
1800         ----          1500  1700         po90.1700    --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1
```

EVPN-MPLS L2CP Tunneling

EVPN-MPLS services shall support transparent L2 control plane protocol tunneling via network tunnels between CE's, via Sub-ifp framework support. The protocols which are tunneled are controlled by configuration at parent Interface (of A/C ports).The below list of L2 control plane BPDU shall be transparently tunneled across EVPN-MPLS networks based on egress tunnels when Tunnel action is configured.

- dot1x
- efm
- elmi
- lldp
- xSTP
- lacp

In case of action "DISCARD" and "PEER" appropriate behavior should see.

- PEER - the corresponding L2 control packet shall be uplifted to the CPU/control plane for processing.
- DISCARD - the corresponding L2 control packets are dropped at node.

Default behavior is PEER.

Topology

See Figure 1-1 and Figure 1-3.

Note: L2CP should be enabled in all PEs access interface to have end to end traffic.

L2CP Configurations

(config)#in xe1	Entering into interface level of access side interface
(config-if)#l2protocol <protocol> tunnel	Enabling tunnel for the L2CP protocol
(config-if)#l2protocol <protocol> peer	Enabling peer for the L2CP protocol
(config-if)#l2protocol <protocol> discard	Enabling discard for the L2CP protocol

Validation

```
PE2#show l2protocol processing interface <interface>
Bridge   Interface Name  Protocol     Processing Status      Hardware Status
======   ==============  ========     =================      ===============
```

```
-        xe8             stp          Tunnel                 Peer
-        xe8             lacp         Tunnel                 Peer
-        xe8             dot1x        Peer                   Peer
-        xe8             lldp         Peer                   Peer
-        xe8             efm          Discard                Discard
-        xe8             elmi         Discard                Discard
-        xe8             synce        Discard                Discard
PE3#show l2protocol interface po1 counters
Interface po1
Peer                 :  lacp                  : 94
Peer                 :  stp                   : 298
Peer                 :  elmi                  : 172
Peer                 :  dot1x                 : 172
Discard              :  stp                   : 6558
Discard              :  elmi                  : 8326
Discard              :  dot1x                 : 9839
```

Note: Tunnel counter won't get incremented as per design.

```
PE4#show interface counters queue-stats
E - Egress, I - Ingress, Q-Size is in bytes
 * indicates monitor is active
+-------------+-------------------+--------+-----------------+-------------------+----------------+-------------------+
|  Interface  |   Queue/Class-map  | Q-Size |     Tx pkts     |       Tx bytes     |  Dropped pkts   |   Dropped bytes   |
+-------------+-------------------+--------+-----------------+-------------------+----------------+-------------------+
 cpu          reserved-mc      (E) 2097152  6                522               0                0
 cpu          bgp              (E) 1048576  2                145               0                0
 cpu          rsvp-ldp         (E) 1048576  7                1060              0                0
 cpu          bpdu             (E) 1048576  6481             4830520           5126             3815132
 ge6          q0               (E) 1253376  350              258691            0                0
 ge6          q6               (E) 1253376  114              10338             0                0
 ge7          q0               (E) 1253376  6                2708              0                0
 ge7          q6               (E) 1253376  2                186               0                0
 ge8          q0               (E) 1253376  5177             3859861           0                0
 xe12         q6               (E) 12517376 6                517               0                0
 xe15         q0               (E) 12517376 2                1281              0                0
 xe16         q0               (E) 12517376 2253             1694682           0                0
```

Note: CPU drop counters will increment for both peer and discard as per design.

EVPN-MPLS MAC Statistics

MAC Statistics feature provides statistics based on number of MAC's routes learned during ELAN and ETREE EVPN-MPLS service. Generic show command supported for both MH and SH services.

"show evpn mpls route-count" is used by admin to fetch all the three route type count (MAC-Only, MAC-IPV4, MAC-IPV6) for per VPN-ID of an EVPN MPLS service and/or route-type.

The details of routes can be fetched via "show evpn mpls nd-cache", "show evpn mpls arp-cache" and "show evpn mpls mac table".

MAC Statistics functionality is "Not Applicable" for EVPN E-LINE service as its point-2-point and does not have MAC advertisements functionality.

Topology

See Figure 1-1 and Figure 1-3.

Configurations

Refer to above configurations to bring up the EVPN service for both SH andMH. No specific configuration needed to get the show command output. Based on the installed service and traffic below route count will be fetched.

Validation

```
PE1#show evpn mpls route-count
EVPN-MPLS Active route count information
====================================
Max route count    : 32768
Active route count: 51
---------------------------------------------
 VNID     Total     MACONLY  MACIPv4  MACIPv6
---------------------------------------------
 602      17        7        5        5
 601      17        7        5        5
 801      17        7        5        5
 802      0         0        0        0
Total number of entries are 4
```

EVPN-MPLS Control-Word Support

A control-word is 4-byte optional field inserted between MPLS label stack & MPLS payload in data traffic as demarcation between MPLS labels & payload to distinguish a PW payload from an IP payload carried over the MPLS LSP, so that LSR or transit node which does deep packet inspection should not treat PW payload as IP payload and result in incorrect ECMP/load-sharing.

Some of salient points for support provided in OcNOS:

- control-word is applicable for both L2-EVPN (E-LAN, E-LINE etc) service data traffics and not applicable for L3-EVPN (IRB) traffic.
- control-word is based on static-CLI configurable along with any EVPN instance creation.

  `hardware-profile filter evpn-mpls-cw enable` CLI must be configured for Control-word Support.

  System requires reboot once after hardware profile filter control-word enabled.

Topology

See Figure 1-1 and Figure 1-3.

Note: Control-word should be symmetrically enabled/disabled across all PE nodes to have end to end non-malformed traffic handling.

EVPN-MPLS Control-Word Configurations

Refer to EVPN MPLS Single Homing configurations to bring up the EVPN service for SH.

PE1: EVPN and MAC VRF Mapping

`(config)#hardware-profile filter evpn-mpls-cw enable`	Enable hardware profile filter evpn-mpls-cw for Control-word support
`(config)#evpn mpls id 2 xconnect target-mpls-id 252 control-word`	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252 along with control-word
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Mapping vrf "vrf2" to EVPN-VPWS identifier

(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001 control-word	Configure the EVPN-VPLS identifier with identifier 1001 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: EVPN and VRF Mapping

(config)#hardware-profile filter evpn-mpls-cw enable	Enable hardware profile filter evpn-mpls-cw for Control-word support
(config)#evpn mpls id 252 xconnect target-mpls-id 2 control-word	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-ELINE identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 1001 control-word	Configure the EVPN-ELAN identifier with identifier 1001 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-ELAN identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

Refer to EVPN MPLS Multihoming configurations to bring up the EVPN service for MH.

PE1: EVPN and VRF Mapping

(config)#hardware-profile filter evpn-mpls-cw enable	Enable hardware profile filter evpn-mpls-cw for Control-word support
(config)#evpn mpls id 1700 xconnect target-mpls-id 1800 control-word	Configure the EVPN-VPWS identifier with source identifier 1700 and target identifier 1800 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#evpn mpls id 3000 control-word	Configure the EVPN-VPLS identifier with identifier 3000 along with control-word
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Mapping vrf "vpls1001" to EVPN-VPLS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: EVPN and MAC VRF Mapping

`(config)#hardware-profile filter evpn-mpls-cw enable`	Enable hardware profile filter evpn-mpls-cw for Control-word support
`(config)#evpn mpls id 1800 xconnect target-mpls-id 1700 control-word`	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1700 along with control-word
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Mapping vrf "test" to EVPN-VPWS identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.
`(config)#evpn mpls id 3000 control-word`	Configure the EVPN-VPLS identifier with identifier 3000 along with control-word
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001`	Mapping vrf "vpls1001" to EVPN-VPLS identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

PE3: EVPN and MAC VRF Mapping

`(config)#hardware-profile filter evpn-mpls-cw enable`	Enable hardware profile filter evpn-mpls-cw for Control-word support
`(config)#evpn mpls id 1800 xconnect target-mpls-id 1700 control-word`	Configure the EVPN-VPWS identifier with source identifier 1800 and target identifier 1800 along with control-word
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Mapping vrf "test" to EVPN-VPWS identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.
`(config)#evpn mpls id 3000 control-word`	Configure the EVPN-VPLS identifier with identifier 3000 along with control-word
`(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001`	Mapping vrf "vpls1001" to EVPN-VPLS identifier
`(config-evpn-mpls)#commit`	Commit the transaction.
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

Validation

`show running-config evpn mpls` should display control-word configuration along EVI instance. Traffic validations are performed using packet capture to observe 4-byte control word present in data traffic.

EVPN-MPLS RSVP Multipath

EVPN-MPLS services with RSVP multipath as a transport provides, Multiple RSVP tunnels which are grouped in ECMP/Multipath group to do load sharing for better optimized and efficient usages of multiple RSVP trunks towards the same Destination.

At ingress node the traffic is load-balanced based on the configured hash (L3 src/dest IP/port, L2 src/dst mac, or in-label if intermediate Autonomous segments). Each LSP path within multipath group can provide individual protection for each path (facility, 1-to-1, secondary).

Each tunnel path in multipath group cost may vary (can have different hop, with consideration for load-balancing the traffic).

Unicast traffic is load shared across all the available multipath member (but not mandatory always) where as in case of BUM only the Active member carries traffic. Addition/deletion should not have impact in traffic in case of unicast, and switchover time is not guaranteed <50ms in case of BUM traffic.

This feature supports across all EVPN service as both SH and MH modes and only BUM Traffic not supported for ELINE service alone as per RFC standard.

Topology

See Figure 1-1, Figure 1-3, Figure 1-5.

Multi Path Configurations

See the previous configurations to bring up the EVPN service for both SH and MH. Transport alone we need to change it from LDP/RSVP to RSVP Multipath as per below configurations.

`(config)#router rsvp`	Creation of RSVP
`(config-router)#int xe1`	Entering into interface level
`(config-if)#enable-rsvp`	Associate the configured RSVP to the exit interface.
`(config-router)#int xe2`	Creation into interface level
`(config-if)#enable-rsvp`	Associate the configured RSVP to the exit interface.
`(Config)#rsvp-multipath MP1`	Create an RSVP multipath group 1
`(config-multipath)#description To-PE3-SH-ELINE-ELAN-ETREE`	RSVP multipath specific description
`(config-multipath)#to 7.7.7.7`	RSVP multipath destination prefix
`(config)# rsvp-path P1_PE3`	Path for Resource Reservation Protocol (RSVP) with Name
`(config-path)# 10.1.24.2 loose`	Configure this explicit route path as a loose or strict hop
`(config-path)#exit`	Exit Path mode.
`(config)# rsvp-path P2_PE3`	Path for Resource Reservation Protocol (RSVP) with Name
`(config-path)# 10.1.34.2 loose`	Configure this explicit route path as a loose or strict hop
`(config-path)#exit`	Exit Path mode.
`(config)#rsvp-trunk T1_PE3`	Create an RSVP trunk T1 and enter the Trunk mode.
`(config-trunk)#primary path P1_PE3`	Specify an RSVP path to be used
`(config-trunk)#to 7.7.7.7`	Specify the IPv4 egress (destination point) for the LSP
`(config-trunk)#multipath-group MP1`	Associating the MP member to the RSVP trunk
`(config)#rsvp-trunk T2_PE3`	Create an RSVP trunk T1 and enter the Trunk mode.
`(config-trunk)#primary path P2_PE3`	Specify an RSVP path to be used
`(config-trunk)#to 7.7.7.7`	Specify the IPv4 egress (destination point) for the LSP
`(config-trunk)#multipath-group MP1`	Associating the MP member to the RSVP trunk
`(config-trunk)#exit`	Exit trunk mode.
`(config)#commit`	Commit candidate configuration to be running configuration

Validation

Below command shows RSVP multipath group info per VPN-ID/destination.

```
PE3#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
 (*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+========+===============+=========+========+========+=========+============+========+======
======+========
                                                           Local            Remote           RSVP-Multipath         Underlay
 Destination    Status     VPN-ID    Policy         MC-Label  UC-Label  MC-Label  UC-Label  Grp-Name     NHLFE-ix  NW-Intf
NW-Label
================+===========+========+===============+=========+========+========+=========+============+========+======
======+========
 7.7.7.7        Installed  1601      --              642       20        642       19        MP2          10        NA          NA
 7.7.7.7        Installed  601       --              640       17        640       17        MP2          10        NA          NA
 7.7.7.7        Installed  1801      --              643       21        643       20        MP2          10        NA          NA
 7.7.7.7        Installed  801       --              641       18        641       18        MP2          10        NA          NA
 7.7.7.7        Installed  1601      --              642       20        18        643       MP2          19        NA          NA
 7.7.7.7        Installed  601       --              640       17        16        640       MP2          19        NA          NA
 7.7.7.7        Installed  1801      --              643       21        19        644       MP1          19        NA          NA
 7.7.7.7        Installed  1601      --              642       20        640       17        MP1          12        NA          NA
 7.7.7.7        Installed  1801      --              643       21        641       18        MP1          12        NA          NA

Total number of entries are 9
PE3#show evpn mpls xc tunnel label
EVPN-MPLS Network tunnel labels
 (*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+========+========+===============+========+========+============+========+============+===
======
                             Local     Remote                      Local     Remote       RSVP-Multipath         Underlay
 Destination     Status      VPWS-ID   VPWS-ID   Policy          UC-Label  UC-Label  Grp-Name     NHLFE-ix  NW-Intf      NW-
Label
================+===========+========+========+===============+========+========+============+========+============+===
======
 7.7.7.7         Installed   501       1         --              16        16        MP2          13        NA           NA
 7.7.7.7         Installed   1501      1001      --              19        16        MP1          2         NA           NA

Total number of entries are 2
```

Below show command gives info about which MP member carries traffic.

```
PE3#show mpls counters rsvp multipath-name MP2

Tunnel-id 5008 Extended Tunnel-ID 3.3.3.3Egress 7.7.7.7
 lsp-name : T1_PE3-Primary                             [Ingress]
 lsp-ingress : 3.3.3.3 lsp-id : 2208
 Rx pkts : n/a                  Rx bytes : n/a
 Tx pkts : 17210                Tx bytes : 80077843

Tunnel-id 5009 Extended Tunnel-ID 7.7.7.7 Egress 3.3.3.3
 lsp-name : T2_PE3-Primary                             [Ingress]
 lsp-ingress : 3.3.3.3          lsp-id : 2209
 Rx pkts : n/a                  Rx bytes : n/a
 Tx pkts : 16904                Tx bytes : 78376789
```

Below commend gives ingress and egress evpn mpls counters during bi-directional traffic for BUM and unicast traffic per VPN id.

```
PE3#show evpn mpls counters network ingress
+----------+-----------+-----------+
|  VPN-ID  |    BUM    |  Unicast  |
|          | RX (pkts) | RX (pkts) |
+----------+-----------+-----------+
 501        0           0
 601        0           0
 801        0           0
 1501       0           0
 1601       131654      0
 1801       131682      0
PE3#
PE3#
PE3#show evpn mpls counters network egress
```

```
+----------+---------------+-----------+-----------+
|  VPN-ID  |  DESTINATION  |    BUM    |  Unicast  |
|          |     PEER      | TX (pkts) | TX (pkts) |
+----------+---------------+-----------+-----------+
 1601        3.3.3.3         264177      0
 501         3.3.3.3         0           0
 601         3.3.3.3         0           0
 1801        3.3.3.3         264312      0
 801         3.3.3.3         0           0
 1601        8.8.8.8         264439      0
 601         8.8.8.8         0           0
 1801        8.8.8.8         264440      0
 1601        4.4.4.4         264503      0
 1501        4.4.4.4         0           0
 1801        4.4.4.4         264530      0
```

EVPN-ELINE CFM Single Homing

CFM (as per IEEE 802.1ag 2007) provides capabilities useful for detecting, verifying and isolating connectivity failures in Virtual Bridged Local Area Networks through Continuity Check, Loop Back and Link Trace protocols. These capabilities can be used in networks operated by multiple independent organizations, each with restricted access to each other's equipment.

The network administrator is generally informed about the failure in the connection based on the reception of Continuity Check Messages or by the user. The administrator can then initiate Loop Back or Link Trace accordingly to quickly determine and then isolate the fault condition.

The CFM information is conveyed in Protocol frames called CFM Protocol Data Units (CFM PDUs). The CFM PDUs contain the appropriate control and status information used to detect, verify and isolate faults. It also contains information for path discovery in CFM-enabled links.

Currently, supported only for EVPN-ELINE Single home and up MEP service on both Q1 and Q2 platforms.

Topology

The diagram depicts the Single Homed topology for the EVPN MPLS configuration examples that follow.

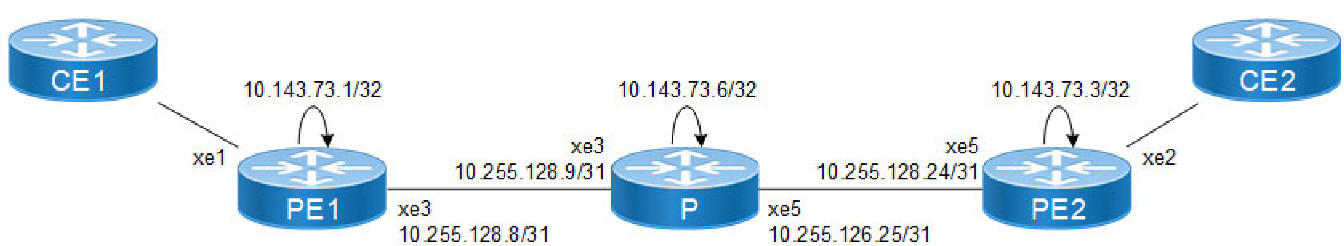

Figure 1-5: EVPN MPLS Single Homing configuration

Prerequisite

Configure below hardware-profile commands related to CFM in configuration mode and reboot the nodes.

```
hardware-profile filter cfm-domain-name-str enable
```

```
hardware-profile statistics cfm-ccm enable
```

PE1: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.1/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit candidate configuration to be running configuration

PE1: Global EVPN MPLS Command

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS
`(config)#commit`	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
`(config)#evpn mpls vtep-ip-global 10.143.73.1`	Configuring VTEP global IP to loopback IP

PE1: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`PE1(config-router)#router-id 10.143.73.1`	Set the router ID to IP address 10.143.73.1
`PE1(config-router)#transport-address ipv4 10.143.73.1 0`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address
`PE1(config-router)#targeted-peer ipv4 10.143.73.3`	Configure targeted peer.
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config)#commit`	Commit candidate configuration to be running configuration

PE1: Interface Configuration Network Side

`(config)#interface xe3`	Enter the Interface mode for xe3
`(config-if)#ip address 10.255.128.2/31`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit candidate configuration to be running configuration

Note: For RSVP Configuration refer RSVP-TE Configuration.

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-ID configurations
(config-router)#network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.2/31 area 0.0.0.0	Advertise xe3 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE1: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.3 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE1: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE1: EVPN and VRF Mapping

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 252
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

(config)#interface xe6	Enter the Interface mode for xe6.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe6.2 switchport	Creating L2 sub interface of physical interface xe6

`(config-if)#encapsulation dot1q 2`	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
`(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-access-if)#map vpn-id 2`	Map vpn-id 252 to interface xe2.2 (VPWS)
`(config-access-if)#exit`	Exiting out of access interface mode
`(config-if)#commit`	Commit candidate configuration to be running configuration

PE1: CFM Configuration

`(config)#hardware-profile filter cfm-domain-name-str enable`	Configure cfm-domain-name-str profile to enable cfm
`(config)#ethernet cfm domain-type character-string domain-name MD-01 level 2 mip-creation none`	Create CFM domain for Evpn ELine with type as character string and set mip creation to none
`(config-ether-cfm-mpls-md)#service ma-type string ma-name S1`	Create ma type with string and set mip creation to none
`(config-ether-cfm-mpls-ma)# evpn 2`	Configure evpn <Evpn-id>
`(config-ether-cfm-mpls-ma)#ethernet cfm mep up mpid 8191 active true evpn 2`	Create up-mep for local evpn id 2
`(config-ether-cfm-mpls-ma-mep)#cc multicast state enable`	Enable cc multicast
`(config-ether-cfm-mpls-ma-mep)#exit-ether-ma-mep-mode`	Exit Ethernet ma-mep-mode
`(config-ether-cfm-mpls-ma)#mep crosscheck mpid 8000`	Configure cross check to remote mep for vlan 2
`(config-ether-cfm-mpls-ma)#cc interval 2`	Enable cc interval with value 2 i.e 10 milliseconds
`(config-ether-cfm-mpls-ma)#exit-ether-ma-mode`	Exit ethernnet ma mode
`(config-ether-cfm-mpls-md)#exit`	Exit Ethernet cfm mode
`(config)#exit`	Exit from config mode
`(config)#commit`	Commit candidate configuration to be running configuration

P: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.2/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit candidate configuration to be running configuration

P: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`PE1(config-router)#router-id 10.143.73.2`	Set the router ID to IP address 10.143.73.2

PE1(config-router)#transport-address ipv4 10.143.73.2 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

P: Interface Configuration

(config)#interface xe3	Enter the Interface mode for xe3
(config-if)#ip address 10.255.128.3/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.22/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

P: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.2	Setting the Router ID as Loopback IP
(config-router)#network 10.143.73.2/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.22/31 area 0.0.0.0	Advertise xe5 network address in OSPF
(config-router)#network 10.255.128.3/31 area 0.0.0.0	Advertise xe3 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: Global LDP

(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3
PE1(config-router)#transport-address ipv4 10.143.73.3 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 10.143.73.1	Configure targeted peer.
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: Global EVPN MPLS Command

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring VTEP global IP to loopback IP
(config)#commit	Commit candidate configuration to be running configuration

PE2: Interface Configuration Network Side

(config)#interface xe5	Enter the Interface mode for xe5
(config-if)#ip address 10.255.128.23/31	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-ID configurations
(config-router)#network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)#network 10.255.128.23/31 area 0.0.0.0	Advertise xe5 network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

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PE2: BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)#neighbor 10.143.73.1 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)#address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)#neighbor 10.143.73.1 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exiting of Address family mode
(config-router)#commit	Commit candidate configuration to be running configuration

PE2: MAC VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.3:2	Configuring Route-Distinguisher value 10.143.73.3:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode
(config)#commit	Commit candidate configuration to be running configuration

PE2: EVPN and VRF Mapping

(config)#evpn mpls id 252 xconnect target-mpls-id 2	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-ELINE identifier
(config-evpn-mpls)#commit	Commit candidate configuration to be running configuration
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration:

(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)#description access-side-int	Giving Interface Description
(config-if)#interface xe2.2 switchport	Creating L2 sub interface of physical interface xe2
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-access-if)#map vpn-id 252	Map vpn-id 252 to interface xe2.2 (VPWS)
(config-access-if)#exit	Exiting out of access interface mode
(config-if)#commit	Commit candidate configuration to be running configuration

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PE2: CFM Configuration

(config)#hardware-profile filter cfm-domain-name-str enable	Configure cfm-domain-name-str profile to enable cfm
(config)#ethernet cfm domain-type character-string domain-name MD-01 level 2 mip-creation none	Create CFM domain for Evpn ELine with type as character string and set mip creation to none
(config-ether-cfm-mpls-md)#service ma-type string ma-name S1	Create ma type with string and set mip creation to none
(config-ether-cfm-mpls-ma)# evpn 252	Configure evpn <Evpn-id>
(config-ether-cfm-mpls-ma)#ethernet cfm mep up mpid 8000 active true evpn 252	Create up-mep for local evpn id 252
(config-ether-cfm-mpls-ma-mep)#cc multicast state enable	Enable cc multicast
(config-ether-cfm-mpls-ma-mep)#exit-ether-ma-mep-mode	Exit Ethernet ma-mep-mode
(config-ether-cfm-mpls-ma)#mep crosscheck mpid 8191	Configure cross check to remote mep for vlan 2
(config-ether-cfm-mpls-ma)#cc interval 2	Enable cc interval with value 2 i.e 10 milliseconds
(config-ether-cfm-mpls-ma)#exit-ether-ma-mode	Exit ethernnet ma mode
(config-ether-cfm-mpls)#exit	Exit Ethernet cfm mode
(config)#exit	Exit from config mode
(config)#commit	Commit candidate configuration to be running configuration

Validation

PE1

```
PE1#show evpn mpls xconnect id 2
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                           Remote       Connection-Details
================================ ============
====================================================================================
VPN-ID      EVI-Name      MTU   VPN-ID       Source       Destination                 PE-IP           MTU   Type   NW-Status
================================ ============
====================================================================================
2           ----         1500  252         xe6.2       --- Single Homed Port ---     10.143.73.3     1500  AC-NW  NW-SET

Total number of entries are 1

PE1#show ethernet cfm errors domain MD-01

Domain Name         Level     MEPID     Defects
-----------------------------------------------
MD-01               2         8191      .....


1. defRDICCM    2. defMACstatus  3. defRemoteCCM
4. defErrorCCM  5. defXconCCM
```

```
PE1#show ethernet cfm ma status domain MD-01 ma-name S1
MA NAME                  STATUS
-------------------------------
     S1                  Active

PE1#show ethernet cfm maintenance-points local mep domain MD-01 ma-name S1
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address    Def Port  MD Name
---------------------------------------------------------------------------
8191 Up  2   Enable  Installed  10 ms    e8c5.7a78.7124 F   xe6.2 MD-01

PE1#show ethernet cfm maintenance-points remote domain MD-01 ma-name S1
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 8191      8000       2         Yes       False  b86a.97cb.6c6e Configured

PE1#show ethernet cfm maintenance-points remote mpid 8191 domain MD-01 ma-name S1
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 8191      8000       2         Yes       False  b86a.97cb.6c6e    Configured

PE1#ping ethernet mac b86a.97cb.6c6e unicast source 8191 domain MD-01 ma-name S1
 success rate is  100 (5/5)

PE1#traceroute ethernet b86a.97cb.6c6e mepid 8191 domain MD-01 ma-name S1
 MP Mac         Hops  Relay-action          Ingress/Egress  Ingress/Egress action
b86a.97cb.6c6e   1     RlyHit                Ingress         IngOK

PE1#show ethernet cfm statistics mep 8191 domain MD-01

 CFM Statistics for MEP 8191 of MD MD-01
 =====================================
Continuity Check Messages
   CCM Sent               : CCM Stats Profile Disabled
   CCM Received           : CCM Stats Profile Disabled

Loop Back Messages
   LBM Sent               : 5
   LBR Received(Valid)    : 5
   LBR Received(Bad msdu) : 0
   LBR Received(Out-of-Seq): 0

Link Trace Messages
   LTM Sent               : 1
   LTR Sent               : 0
   LTR Received(Valid)    : 1
   LTR Received(unexpected): 0
```

PE2

```
PE2#show evpn mpls xconnect id 252
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
===================================================================================
VPN-ID      EVI-Name     MTU   VPN-ID      Source      Destination                 PE-IP          MTU   Type   NW-Status
================================ ============
===================================================================================
252         ----         1500  2           xe2.2      --- Single Homed Port ---     10.143.73.1     1500  AC-NW  NW-SET

Total number of entries are 1


PE2#show ethernet cfm errors domain MD-01
```

```
Domain Name         Level     MEPID     Defects
-----------------------------------------------
MD-01               2         8000      .....


1. defRDICCM    2. defMACstatus  3. defRemoteCCM
4. defErrorCCM  5. defXconCCM

PE3#show ethernet cfm ma status domain MD-01 ma-name S1
ma-name S1
MA NAME                  STATUS
-------------------------------
     S1                  Active


PE2#show ethernet cfm maintenance-points local mep domain MD-01 ma-name S1
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address    Def Port  MD Name
---------------------------------------------------------------------------
8000 Up  2   Enable  Installed  10 ms    b86a.97cb.6c6e F   xe2.2 MD-01

PE3#show ethernet cfm maintenance-points remote domain MD-01 ma-name S1
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 8000      8191       2         Yes       False  e8c5.7a78.7124 Configured

PE2#show ethernet cfm maintenance-points remote mpid 8000 domain MD-01 ma-name S1
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 8000      8191       2         Yes       False  e8c5.7a78.7124    Configured


PE2#traceroute ethernet e8c5.7a78.7124 mepid 8000 domain MD-01 ma-name S1
 MP Mac         Hops  Relay-action          Ingress/Egress  Ingress/Egress action
e8c5.7a78.7124   1     RlyHit                 Ingress         IngOK

PE2#show ethernet cfm statistics mep 8000 domain MD-01 ma-name S1

 CFM Statistics for MEP 8000 of MD MD-01
 ======================================
Continuity Check Messages
   CCM Sent               : CCM Stats Profile Disabled
   CCM Received           : CCM Stats Profile Disabled

Loop Back Messages
   LBM Sent               : 5
   LBR Received(Valid)     : 5
   LBR Received(Bad msdu)  : 0
   LBR Received(Out-of-Seq): 0

Link Trace Messages
   LTM Sent               : 1
   LTR Sent               : 1
   LTR Received(Valid)     : 1
   LTR Received(unexpected): 0
```

CHAPTER 2 EVPN MPLS IRB Configuration

This chapter includes step-by-step configurations for EVPN MPLS IRB.

Overview

EVPN provides an extensible and flexible multihoming VPN solution over an MPLS/IP network for intra-subnet connectivity among Tenant Systems (TSs) and end devices that can be physical or virtual, where an IP subnet is represented by an EVPN instance (EVI) for a VLAN-based service or by an (EVI, VLAN) association for a VLAN-aware bundle service. However, there are scenarios for which there is a need for a dynamic and efficient inter-subnet connectivity among these Tenant Systems and end devices while maintaining the multihoming capabilities of EVPN. This document describes an Integrated Routing and Bridging (IRB) solution based on EVPN to address such requirements

Integrated Routing and Bridging combines switching of tenant data with routing into different VNID of the same tenant. This is accomplished by having a unique per-tenant layer 3 IP-VRF across all PEs hosting tenant systems for that tenant and the layer-2 MAC VRFs (mapping to one or more bridged domains (VNIDS)) belonging to that tenant on different PEs being mapped to the common IP-VRF through logical interfaces called IRB interfaces. The MAC-VRF tables are used for switching intra-subnet communication whereas the IP-VRF tables are used for routing inter-subnet traffic.

IRB has two modes of working.

- Asymmetric IRB (Anycast and Centralized)
- Symmetric IRB (Distributed)

Asymmetric IRB

In asymmetric IRB, the lookup operation is asymmetric and the ingress PE performs three lookups, whereas the egress PE performs a single lookup -- i.e., the ingress PE performs a MAC lookup, followed by an IP lookup, followed by a MAC lookup again. The egress PE performs just a single MAC lookup as depicted in following figure:

```
     Ingress PE                          Egress PE
  +-------------------+          +-------------------+
  |                   |          |                   |
  |    +-> IP-VRF ->  |          |       IP-VRF      |
  |    |          |   |          |                   |
  |   BT1        BT2  |          |  BT3        BT2   |
  |    |          |   |          |              | |  |
  |    |          +--|--->----|--------------+ |  |
  |    |              |          |                v  |
  +-------------------+          +----------------|--+
       ^                                          |
       |                                          |
 TS1->-+                                          +->-TS2
```

Figure 2-1: Asymmetric IRB

In other words, each PE participating in asymmetric IRB MUST maintain ARP entries for remote hosts (hosts connected

to other PEs) as well as maintain MAC-VRFs/BTs and IRB interfaces for ALL subnets in an IP-VRF, including subnets that may not be locally attached.

Symmetric IRB

In symmetric IRB, as its name implies, the lookup operation is symmetric at both the ingress and egress PEs -- i.e., both ingress and egress PEs perform lookups on both MAC and IP addresses. The ingress PE performs a MAC lookup followed by an IP lookup, and the egress PE performs an IP lookup followed by a MAC lookup, as depicted in the following figure:

```
          Ingress PE                   Egress PE
    +-------------------+        +------------------+
    |                   |        |                  |
    |    +-> IP-VRF ----|---->---|-----> IP-VRF -+  |
    |    |              |        |               |  |
    |   BT1        BT2  |        |  BT3         BT2 |
    |    |              |        |               |  |
    |    ^              |        |               v  |
    |    |              |        |               |  |
    +-------------------+        +------------------+
         ^                                       |
         |                                       |
   TS1->-+                                       +->-TS2
```

Figure 2-2: Symmetric IRB

Therefore, in symmetric IRB, there is no need for the ingress PE to maintain ARP entries for the association of the destination TS2's IP and MAC addresses in its ARP table. Each PE participating in symmetric IRB only maintains ARP entries for locally connected hosts and MAC-VRFs/BTs for only locally configured subnets.

Route Types

These EVPN route types are supported:

- Route Type 1: Ethernet Auto-Discovery (AD) Route

  The Ethernet (AD) routes are advertised on per EVI and per ESI basis. These routes are sent per ES. They carry the list of EVIs that belong to the ES.

  This route is advertised when multihomed CEs already exist.

- Route Type 2: MAC/IP Advertisement Route

  The host's IP and MAC addresses are advertised to the peers within NLRI. The control plane learning of MAC addresses reduces unknown unicast flooding.

- Route Type 3: Inclusive Multicast Ethernet Tag Route

  This route establishes the connection for broadcast, unknown unicast, and multicast (BUM) traffic from a source PE to a remote PE.

  This route is advertised on per VLAN and per ESI basis.

- Route Type 4: Ethernet Segment Route

  Ethernet segment routes enable to connect a CE device to two or PE devices.

  Ethernet segment routes enable the discovery of connected PE devices that are connected to the same Ethernet segment.

- Route Type 5: IP prefix Route

An IP prefix route provides encoding for inter-subnet forwarding. In the control plane, EVPN Type 5 routes are used to advertise IP prefixes for inter-subnet connectivity across data centers.

In EVPN-VPWS the auto-discovery of peer PE nodes is done with the pair of Ethernet A-D routes. Inclusive Multicast route does not have participation on auto-discovery unlike ELAN-EVPN VPLS. Since there is no MAC-advertisement, MAC-IP route is not applicable.

Note:

1. RD value should be unique for multihoming nodes.
2. ANYCAST gateway MAC is mandatory on multihoming nodes.
3. "rewrite pop" is mandatory on access interface.
4. arp-nd refresh timer needs to be configured to avoid ARP table getting clear after ARP timeout.

EVPN MPLS IRB Symmetric Distributed mode

Topology

Figure 2-3 depicts the EVPN MPLS IRB with LDP as underlay MPLS path.

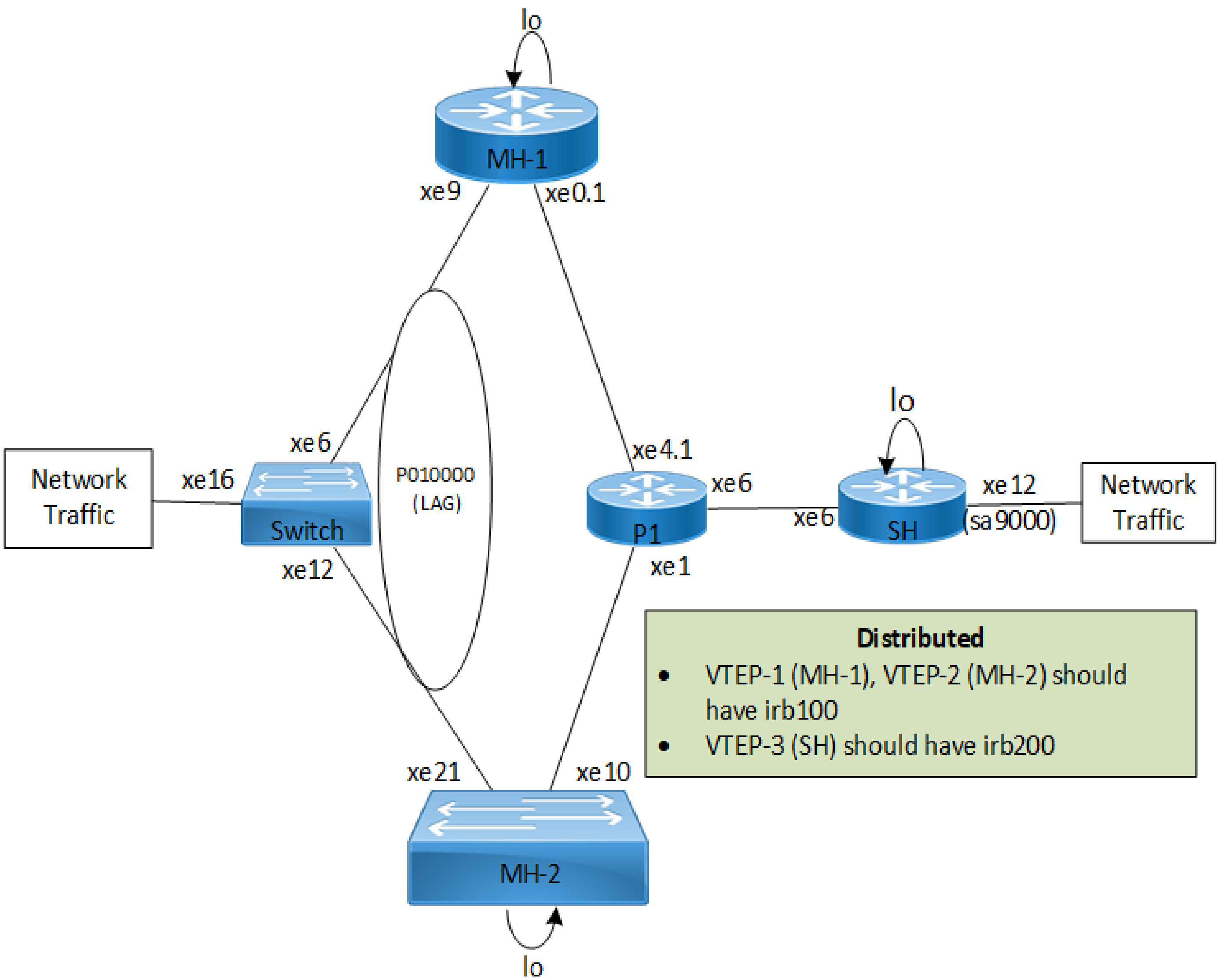

Figure 2-3: EVPN MPLS IRB Distributed configuration

Configurations

SH1

Enable EVPN MPLS and IRB

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS globally
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB globally

Loopback Interface

`(config-if)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)# ip address 5.5.5.5/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

Configure MAC VRF

`(config)#mac vrf green`	Create MAC VRF green.
`(config-vrf)# rd 5.5.5.5:200`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto route target (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode

Configure IP VRF

`(config)#ip vrf evpn`	Configure IP VRF evpn.
`(config-vrf)# rd 30:200`	Configure route distinguisher
`(config-vrf)# route-target both 100:200`	Configure route target
`(config-vrf)# l3vni 20000`	Configure L3 VNID for routing
`(config-vrf)#exit`	Exit VRF mode

Configuring IRB interface

`(config)#interface irb200`	Create IRB interface irb100
`(config-irb-if)# ip vrf forwarding evpn`	Map L3 VRF to the IRB interface
`(config-irb-if)# ip address 70.70.1.1/24`	Assign IP address
`(config-irb-if)#exit`	Exit interface mode

Creating EVPN MPLS ID

`(config)#evpn mpls vtep-ip-global 5.5.5.5`	Configure VTEP global IP
`(config)#evpn mpls id 200`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachability-protocol evpn-bgp green`	Map the MAC VRF green
`(config-evpn-mpls)# evpn irb irb200`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 5.5.5.5`	Enter LDP router-id
`(config-router)# transport-address ipv4 5.5.5.5`	Configure LDP transport address

(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe6	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 30.30.30.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router id
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode

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(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config-if)#interface sa9000	Creating Static LAG interface
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)#exit	Exiting out of interface mode
(config-if)#interface sa9000.200 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 200	Map VPN-ID 200
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface xe12	Enter the Interface mode
(config-if)# static-channel-group 9000	Map the physical interface xe12 as static LAG member
(config-if)#exit	Exit interface mode

P1

Loopback Interface:

#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 4.4.4.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 4.4.4.4	Configure router id
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address
(config-router)#exit	Exit from LDP mode
(config-router)#exit	Exit from LDP mode

Interface Configuration

(config-if)#interface xe4	Enter the Interface mode for xe4.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Enable LDP on the physical interface

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(config)#interface xe4.1	Create sub-interface xe4.1.
(config-if)# description connected-to-MH-1	Configure Interface description
(config-if)# ip address 10.10.10.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter into Interface mode
(config-if)# description connected to MH-2	Configure Interface description
(config-if)# ip address 20.20.20.2/24	Cofigure IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter into Interface mode
(config-if)# description connected to SH	Configure Interface description
(config-if)# ip address 30.30.30.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 4.4.4.4	Setting the Router ID as Loopback IP
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

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MH-1

Enable EVPN MPLS and IRB

`#configure terminal`	Enter configuration mode.
`(config)#hardware-profile filter evpn-mpls-mh enable`	Configure hardware profile to enable EVPN MPLS multi homing in hardware
`(config)#evpn mpls enable`	Enable EVPN MPLS globally
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB globally
`(config)#evpn mpls multihoming enable`	Enable EVPN MPLS multihoming globally

Loopback Interface

`(config-if)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 2.2.2.2/32 secondarysss`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

Configure MAC VRF

`(config-vrf)#mac vrf green`	Create MAC VRF green.
`(config-vrf)# rd 2.2.2.2:200`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto-rt(we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode

Configure IP VRF

`(config)#ip vrf evpn`	Configure IP VRF evpn.
`(config-vrf)# rd 10:200`	Configure route distinguisher
`(config-vrf)# route-target both 100:200`	Configure route target
`(config-vrf)# l3vni 20000`	Configure L3 VNID for routing
`(config-vrf)#exit`	Exit VRF mode

Configure Anycast Gateway MAC

:

`(config)#evpn irb-forwarding anycast-gateway- mac 0011.2233.4455`	Configure anycast gateway MAC globally
`(config)#interface irb100`	Create IRB interface irb100
`(config-irb-if)# ip vrf forwarding evpn`	Map L3 VRF to the IRB interface
`(config-irb-if)# ip address 80.80.1.1/24 anycast`	Assign IP address
`(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac`	Map anycast gateway MAC
`(config-irb-if)#exit`	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 2.2.2.2	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp green	Map the MAC VRF green
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 2.2.2.2	Enter LDP router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe0	Enter the Interface mode for xe0.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Exit from interface xe0
(config)#interface xe0.1	Create subinterface in xe10
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# ip address 10.10.10.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 2.2.2.2	Router-ID configurations
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF.

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BGP Configuration

`(config-router)#router bgp 65010`	Enter the Router BGP mode, ASN: 100
`(config-router)# neighbor 3.3.3.3 remote-as 65010`	Configuring PE2 as iBGP neighbor using it's loopback IP
`(config-router)# neighbor 3.3.3.3 update-source lo`	Source of routing updates as loopback
`(config-router)# neighbor 5.5.5.5 remote-as 65010`	Configuring PE2 as iBGP neighbor using it's loopback IP
`(config-router)# neighbor 5.5.5.5 update-source lo`	Source of routing updates as loopback
`(config-router)# address-family l2vpn evpn`	Entering into address family mode as EVPN
`(config-router-af)# neighbor 3.3.3.3 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# neighbor 5.5.5.5 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# exit-address-family`	Exiting of Address family mode
`(config-router)# address-family ipv4 vrf evpn`	Entering into VRF address family mode
`(config-router-af)# redistribute connected`	Redistribute connected routes to the network
`(config-router-af)# exit-address-family`	Exiting of Address family mode

Access Port Configuration

`(config)#interface xe9`	Enter configuration mode
`(config-if)# mtu 9216`	Configure MTU
`(config-if)# channel-group 10000 mode active`	Configure physical interface xe9 as LAG member po10000
`(config-if)#exit`	Exit from interface xe9
`(config)#interface po10000`	Create LAG interface po10000
`(config-if)# mtu 9216`	Configure MTU
`(config-if)# description connected to Switch`	Configure Interface description
`(config-if)# evpn multi-homed system-mac 0000.1111.aaaa`	Configure system MAC for multi homing
`(config)#interface po10000.100 switchport`	Creating L2 sub interface of physical interface xe9
`(config-if)# encapsulation dot1q 100`	Setting Encapsulation to dot1q with VLAN ID 100
`(config-if)#rewrite pop`	Configure rewrite with action pop
`(config-if)#mtu 9216`	Configure MTU as 9216
`(config-if)# access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-acc-if-evpn)# map vpn-id 100`	Map VPN-ID 202
`(config-acc-if-evpn)#exit`	Exiting out of access interface mode

MH-2

Enable EVPN MPLS and IRB

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mplsmh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config-vrf)#mac vrf green	Create MAC VRF green.
(config-vrf)# rd 3.3.3.3:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto-rt (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf evpn	Configure IP VRF evpn.
(config-vrf)# rd 20:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 20000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC

(config)#evpn irb-forwarding anycastgateway-mac 0011.2233.4455	Configure anycast gateway MAC globally

Configuring IRB interface

(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address

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(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 3.3.3.3	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp green	Map the MAC VRF green
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 3.3.3.3	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe10	Enter the configuration mode.
(config-if)# description connected to P1	Configure Interface description
(config-if)# ip address 20.20.20.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 3.3.3.3	Router-ID configurations
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF.

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BGP Configuration

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)#interface xe21	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe21 as LAG member po10000
(config-if)#exit	Exit from interface xe21
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

Note: Remote entries cannot be fetched from through MAC table/ARP cache/ND cache. However they can be fetched from the BGP table.

MH-1

```
MH-1#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
________________________________________________________________________________________
________________________________________
100      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2          3.3.3.3
100      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2          5.5.5.5
100     ----       --      AC   po10000.100 00:00:00:11:11:aa:aa:00:00:00 ----     DF
----         ----
200      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2          3.3.3.3
200      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2          5.5.5.5
200     ----       --      AC   po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----     DF
----         ----
10000    ----         L3       NW   ----      ----                          ----      -
---      2.2.2.2          3.3.3.3
10000    ----         L3       NW   ----      ----                          ----      -
---      2.2.2.2          5.5.5.5

Total number of entries are 8
MH-1#
MH-1#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
===================================================================================
2.2.2.2          3.3.3.3          Installed     01:16:34      01:16:34      200
2.2.2.2          3.3.3.3          Installed     01:16:34      01:16:34      100
2.2.2.2          3.3.3.3          Installed     01:23:48      01:23:48      10000
2.2.2.2          5.5.5.5          Installed     01:14:59      01:14:59      200
2.2.2.2          5.5.5.5          Installed     01:14:59      01:14:59      100
2.2.2.2          5.5.5.5          Installed     01:23:48      01:23:48      10000

Total number of entries are 6
MH-1#
MH-1#sh evpn mpls mac-table
========================================================================================
==================================================
```

```
                                                     EVPN MPLS MAC Entries
=========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
_________________________________________________________________________________________
__________________________________________________

100        irb100    ----      ----      0011.2233.4455 2.2.2.2
Static Local    -------    0        -------
100        ----      ----      ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0        -------
100       po10000.100 ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Local   -------    0        -------
100        ----      ----      ----      0010.9400.0004 5.5.5.5
Dynamic Remote  -------    0        -------
200        irb200    ----      ----      0011.2233.4455 2.2.2.2
Static Local    -------    0        -------
200        ----      ----      ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0        -------
200       po10000.200 ----      ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Local   -------    0        -------
200        ----      ----      ----      0010.9400.0005 5.5.5.5
Dynamic Remote  -------    0        -------

Total number of entries are : 8

MH-1#
MH-1#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
==============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.1        0011.2233.4455 Static Local   ----
100      80.80.1.2        0010.9400.0001 Dynamic Local  244      2
100      80.80.1.3        9819.2c86.3e01 Static Remote  ----
100      80.80.1.4        0010.9400.0004 Dynamic Remote ----
200      90.90.1.1        0011.2233.4455 Static Local   ----
200      90.90.1.2        0010.9400.0002 Dynamic Local  ----
200      90.90.1.3        9819.2c86.3e01 Static Remote  ----
200      90.90.1.4        0010.9400.0005 Dynamic Remote ----
Total number of entries are 8
MH-1#
MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS

RD[2.2.2.2:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
```

```
00:00:00:11:11:aa:aa:00:00:00  4294967295  19            3.3.3.3         MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19            2.2.2.2         MPLS

RD[3.3.3.3:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19            3.3.3.3         MPLS
MH-1#
MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17            3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17            2.2.2.2         MPLS

RD[2.2.2.2:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18            3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18            2.2.2.2         MPLS

RD[3.3.3.3:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17            3.3.3.3         MPLS

RD[3.3.3.3:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18            3.3.3.3         MPLS
MH-1#
MH-1#sh evpn mpls label esi
S - Self
R - Remote
ESI                            PE-IP-ADDRESS        ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)            19
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            19
MH-1#
MH-1#sh evpn mpls label alias
S - Self
R - Remote
ESI                            PE-IP-ADDRESS        TENANT              ALIAS-LABEL
==========================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)            100                   17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)            200                   18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            100                   17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            200                   18
MH-1#
MH-1#sh bgp l2vpn evpn
BGP table version is 10, local router ID is 2.2.2.2
```

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```
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network         Next Hop           Metric    LocPrf      Weight     Path  Peer
Encap

RD[20:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                      3.3.3.3             0        100       0    ?  3.3.3.3         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                      3.3.3.3             0        100       0    ?  3.3.3.3         MPLS

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                      5.5.5.5             0        100       0    ?  5.5.5.5         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                      5.5.5.5             0        100       0    ?  5.5.5.5         MPLS

RD[2.2.2.2:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                      3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>                   2.2.2.2             0        100      32768  i  ----------      MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                      3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     2.2.2.2             0        100      32768  i  ----------      MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     2.2.2.2             0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                      5.5.5.5             0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                      5.5.5.5             0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                      3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>                   2.2.2.2             0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                      5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>   [3]:[100]:[32,2.2.2.2]
                     2.2.2.2             0        100      32768  i  ----------      MPLS
* i  [3]:[100]:[32,3.3.3.3]
                      3.3.3.3             0        100       0    i  3.3.3.3         MPLS
* i  [3]:[100]:[32,5.5.5.5]
```

```
                        5.5.5.5              0         100        0    i  5.5.5.5         MPLS

RD[2.2.2.2:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
*>                     2.2.2.2              0        100       32768  i  ----------      MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                       2.2.2.2              0        100       32768  i  ----------      MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                       2.2.2.2              0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                        5.5.5.5              0         100        0    i  5.5.5.5         MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                        5.5.5.5              0         100        0    i  5.5.5.5         MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
*>                     2.2.2.2              0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                        5.5.5.5              0         100        0    i  5.5.5.5         MPLS
*>   [3]:[200]:[32,2.2.2.2]
                       2.2.2.2              0        100       32768  i  ----------      MPLS
* i  [3]:[200]:[32,3.3.3.3]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
* i  [3]:[200]:[32,5.5.5.5]
                        5.5.5.5              0         100        0    i  5.5.5.5         MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                       2.2.2.2              0        100       32768  i  ----------      MPLS
*>   [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                       2.2.2.2              0        100       32768  i  ----------      MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                        3.3.3.3              0         100        0    i  3.3.3.3         MPLS
*>i  [3]:[200]:[32,3.3.3.3]
```

```
                      3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                      3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                      3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[5.5.5.5:100]
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [3]:[100]:[32,5.5.5.5]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                      5.5.5.5            0        100       0    i  5.5.5.5        MPLS

Total number of prefixes 45
MH-1#
MH-1#sh bgp l2vpn evpn prefix-route

RD[20:200]
ESI             Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop          Encap     Router-Mac
0               0       24               80.80.1.0       0.0.0.0         16
3.3.3.3          MPLS      e8c5:7ad2:5d98
0               0       24               90.90.1.0       0.0.0.0         16
3.3.3.3          MPLS      e8c5:7ad2:5d98

RD[30:200]
ESI             Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop          Encap     Router-Mac
0               0       24               80.80.1.0       0.0.0.0         16
5.5.5.5          MPLS      9819:2c86:3e01
0               0       24               90.90.1.0       0.0.0.0         16
5.5.5.5          MPLS      9819:2c86:3e01
MH-1#
MH-1#sh bgp l2vpn evpn summary
BGP router identifier 2.2.2.2, local AS number 65010
BGP table version is 10
1 BGP AS-PATH entries
```

```
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
3.3.3.3                4 65010  205        203      9      0      0  01:17:25
10      3      2      2      1      2
5.5.5.5                4 65010  187        197      9      0      0  01:15:01
10      0      6      2      0      2

Total number of neighbors 2

Total number of Established sessions 2
MH-1#
MH-1#sh ip bgp vrf evpn_anycast
BGP table version is 1, local router ID is 90.90.1.1
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path
*>   80.80.1.0/24     0.0.0.0              0        100       32768  ?
* i                   5.5.5.5              0        100       0    ?
* i                   3.3.3.3              0        100       0    ?
*>   90.90.1.0/24     0.0.0.0              0        100       32768  ?
* i                   5.5.5.5              0        100       0    ?
* i                   3.3.3.3              0        100       0    ?

Total number of prefixes 2
MH-1#
MH-1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   3.3.3.3/32         1         3
                                    2        -          Yes   LSP_DEFAULT  25600
xe0.1       No    10.10.10.2
   L>   4.4.4.4/32         2         6
                                    5        -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
   L>   5.5.5.5/32         5         8
                                    7        -          Yes   LSP_DEFAULT  25603
xe0.1       No    10.10.10.2
   L>   20.20.20.0/24      3         6
                                    5        -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
   L>   30.30.30.0/24      4         6
```

```
                              5        -         Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
MH-1#
MH-1#sh ldp session
Peer IP Address          IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                  xe0.1      Passive   OPERATIONAL   30    01:14:50
4.4.4.4                  xe0.1      Passive   OPERATIONAL   30    01:16:35
MH-1#
MH-1#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:39   10.10.10.2     xe0.1                 0
MH-1#
MH-1#sh nvo vxlan l3vni-map
 L3VNI        L2VNI        IRB-interface
===================================
 10000        100          irb100
 10000        200          irb200

MH-1#
```

MH-2

```
MH-2#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
_________________________________________________________________________________________
________________________________________
100      ----         L2       NW   ----      ----                          ----      -
---      3.3.3.3          5.5.5.5
100      ----         L2       NW   ----      ----                          ----      -
---      3.3.3.3          2.2.2.2
100      ----         --       AC   po10000.100 00:00:00:11:11:aa:aa:00:00:00 ----
NON-DF    ----             ----
200      ----         L2       NW   ----      ----                          ----      -
---      3.3.3.3          5.5.5.5
200      ----         L2       NW   ----      ----                          ----      -
---      3.3.3.3          2.2.2.2
200      ----         --       AC   po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----
NON-DF    ----             ----
10000    ----         L3       NW   ----      ----                          ----      -
---      3.3.3.3          5.5.5.5
10000    ----         L3       NW   ----      ----                          ----      -
---      3.3.3.3          2.2.2.2
```

```
Total number of entries are 8
MH-2#
MH-2#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
===================================================================================
3.3.3.3          5.5.5.5          Installed     01:15:41      01:15:41      200
3.3.3.3          5.5.5.5          Installed     01:15:41      01:15:41      100
3.3.3.3          5.5.5.5          Installed     01:24:08      01:24:08      10000
3.3.3.3          2.2.2.2          Installed     01:17:15      01:17:15      200
3.3.3.3          2.2.2.2          Installed     01:17:15      01:17:15      100
3.3.3.3          2.2.2.2          Installed     01:24:08      01:24:08      10000

Total number of entries are 6
MH-2#
MH-2#sh evpn mpls mac-table
=========================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
=========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI              Type
Status     MAC move AccessPortDesc
_________________________________________________________________________________________
__________________________________________________


100        irb100    ----       ----      0011.2233.4455 3.3.3.3
Static Local    -------    0        -------
100        ----      ----       ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0        -------
100        ----      ----       ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
100        ----      ----       ----      0010.9400.0004 5.5.5.5
Dynamic Remote  -------    0        -------
200        irb200    ----       ----      0011.2233.4455 3.3.3.3
Static Local    -------    0        -------
200        ----      ----       ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0        -------
200        ----      ----       ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
200        ----      ----       ----      0010.9400.0005 5.5.5.5
Dynamic Remote  -------    0        -------

Total number of entries are : 8

MH-2#
MH-2#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
=============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
```

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```
___________________________________________________________________________
100      80.80.1.1        0011.2233.4455 Static Local   ----
100      80.80.1.2        0010.9400.0001 Dynamic Remote ----
100      80.80.1.3        9819.2c86.3e01 Static Remote  ----
100      80.80.1.4        0010.9400.0004 Dynamic Remote ----
200      90.90.1.1        0011.2233.4455 Static Local   ----
200      90.90.1.2        0010.9400.0002 Dynamic Remote ----
200      90.90.1.3        9819.2c86.3e01 Static Remote  ----
200      90.90.1.4        0010.9400.0005 Dynamic Remote ----
Total number of entries are 8
MH-2#
MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:100] VRF[red]:
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:200] VRF[blue]:
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS
MH-2#
MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[2.2.2.2:200]
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100] VRF[red]:
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200] VRF[blue]:
ESI                           Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
MH-2#
MH-2#sh evpn mpls label esi
```

```
S - Self
R - Remote
ESI                          PE-IP-ADDRESS       ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)          19
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)          19
MH-2#
MH-2#sh evpn mpls label alias
S - Self
R - Remote
ESI                          PE-IP-ADDRESS       TENANT              ALIAS-LABEL
=======================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)          100                   17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)          200                   18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)          100                   17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)          200                   18
MH-2#
MH-2#sh bgp l2vpn evpn
BGP table version is 16, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network         Next Hop          Metric    LocPrf      Weight     Path  Peer
Encap

RD[10:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0        100       0    ?  2.2.2.2        MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0        100       0    ?  2.2.2.2        MPLS

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     5.5.5.5            0        100       0    ?  5.5.5.5        MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     5.5.5.5            0        100       0    ?  5.5.5.5        MPLS

RD[2.2.2.2:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
```

```
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS

RD[3.3.3.3:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>                 3.3.3.3            0        100      32768  i  ----------      MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                    5.5.5.5            0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                    5.5.5.5            0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>                 3.3.3.3            0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                    5.5.5.5            0        100       0    i  5.5.5.5         MPLS
* i  [3]:[100]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>   [3]:[100]:[32,3.3.3.3]
                   3.3.3.3            0        100      32768  i  ----------      MPLS
* i  [3]:[100]:[32,5.5.5.5]
```

```
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS

RD[3.3.3.3:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>                  3.3.3.3             0        100      32768  i  ----------      MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>                  3.3.3.3             0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
* i  [3]:[200]:[32,2.2.2.2]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>   [3]:[200]:[32,3.3.3.3]
                    3.3.3.3             0        100      32768  i  ----------      MPLS
* i  [3]:[200]:[32,5.5.5.5]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    3.3.3.3             0        100      32768  i  ----------      MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>   [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                    3.3.3.3             0        100      32768  i  ----------      MPLS

RD[5.5.5.5:100]
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [3]:[100]:[32,5.5.5.5]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
```

```
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS

Total number of prefixes 49
MH-2#
MH-2#sh bgp l2vpn evpn prefix-route

RD[10:200]
ESI             Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop          Encap     Router-Mac
0               0       24               80.80.1.0       0.0.0.0         16
2.2.2.2          MPLS      e8c5:7a88:1738
0               0       24               90.90.1.0       0.0.0.0         16
2.2.2.2          MPLS      e8c5:7a88:1738

RD[30:200]
ESI             Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop          Encap     Router-Mac
0               0       24               80.80.1.0       0.0.0.0         16
5.5.5.5          MPLS      9819:2c86:3e01
0               0       24               90.90.1.0       0.0.0.0         16
5.5.5.5          MPLS      9819:2c86:3e01
MH-2#
MH-2#sh bgp l2vpn evpn summary
BGP router identifier 3.3.3.3, local AS number 65010
BGP table version is 16
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                  V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
2.2.2.2                  4 65010  203       207     16      0      0  01:18:08
14      3      6      2      1      2
5.5.5.5                  4 65010  190       202     16      0      0  01:15:43
10      0      6      2      0      2

Total number of neighbors 2

Total number of Established sessions 2
MH-2#
MH-2#sh ip bgp vrf evpn_anycast
BGP table version is 1, local router ID is 90.90.1.1
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric     LocPrf    Weight Path
*>   80.80.1.0/24     0.0.0.0             0         100       32768  ?
* i                   5.5.5.5             0         100       0    ?
```

```
* i                    2.2.2.2              0        100       0    ?
*>   90.90.1.0/24      0.0.0.0              0        100       32768  ?
* i                    5.5.5.5              0        100       0    ?
* i                    2.2.2.2              0        100       0    ?

Total number of prefixes 2
MH-2#
MH-2#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          1         3
                                   2         -           Yes   LSP_DEFAULT  25601
xe10        No    20.20.20.2
   L>   4.4.4.4/32          2         6
                                   5         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
   L>   5.5.5.5/32          5         8
                                   7         -           Yes   LSP_DEFAULT  25602
xe10        No    20.20.20.2
   L>   10.10.10.0/24       3         6
                                   5         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
   L>   30.30.30.0/24       4         6
                                   5         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
MH-2#
MH-2#sh ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
5.5.5.5                   xe10       Passive   OPERATIONAL   30    01:15:31
4.4.4.4                   xe10       Passive   OPERATIONAL   30    01:17:16
MH-2#
MH-2#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:33   20.20.20.2     xe10                  0
MH-2#
MH-2#sh nvo vxlan l3vni-map
 L3VNI        L2VNI        IRB-interface
===================================
 10000        100          irb100
 10000        200          irb200

MH-2#
```

SH

```
SH#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
__________________________________________________________________________________________
________________________________________
100      ----         L2        NW   ----      ----                          ----      -
---      5.5.5.5          2.2.2.2
100      ----         L2        NW   ----      ----                          ----      -
---      5.5.5.5          3.3.3.3
100      ----         --        AC   sa9000.100 --- Single Homed Port ---     ----      -
---      ----             ----
200      ----         L2        NW   ----      ----                          ----      -
---      5.5.5.5          2.2.2.2
200      ----         L2        NW   ----      ----                          ----      -
---      5.5.5.5          3.3.3.3
200      ----         --        AC   sa9000.200 --- Single Homed Port ---     ----      -
---      ----             ----
10000    ----         L3        NW   ----      ----                          ----      -
---      5.5.5.5          2.2.2.2
10000    ----         L3        NW   ----      ----                          ----      -
---      5.5.5.5          3.3.3.3

Total number of entries are 8
SH#
SH#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=====================================================================================
5.5.5.5          2.2.2.2          Installed     01:15:49      01:15:49      200
5.5.5.5          2.2.2.2          Installed     01:15:49      01:15:49      100
5.5.5.5          2.2.2.2          Installed     01:25:33      01:25:33      10000
5.5.5.5          3.3.3.3          Installed     01:15:49      01:15:49      200
5.5.5.5          3.3.3.3          Installed     01:15:49      01:15:49      100
5.5.5.5          3.3.3.3          Installed     01:25:33      01:25:33      10000

Total number of entries are 6
SH#
SH#sh evpn mpls mac-table
==========================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
==========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
```

```
_______________________________________________________________________________________
__________________________________________________

100        ----      ----      ----      0011.2233.4455 2.2.2.2
Static Remote   -------    0        -------
100        irb100    ----      ----      9819.2c86.3e01 5.5.5.5
Static Local    -------    0        -------
100        ----      ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
100        sa9000.100 ----      ----      0010.9400.0004 5.5.5.5
Dynamic Local   -------    0        -------
200        ----      ----      ----      0011.2233.4455 2.2.2.2
Static Remote   -------    0        -------
200        irb200    ----      ----      9819.2c86.3e01 5.5.5.5
Static Local    -------    0        -------
200        ----      ----      ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
200        sa9000.200 ----      ----      0010.9400.0005 5.5.5.5
Dynamic Local   -------    0        -------

Total number of entries are : 8

SH#
SH#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.1        0011.2233.4455 Static Remote  ----
100      80.80.1.2        0010.9400.0001 Dynamic Remote ----
100      80.80.1.3        9819.2c86.3e01 Static Local   ----
100      80.80.1.4        0010.9400.0004 Dynamic Local  ----
200      90.90.1.1        0011.2233.4455 Static Remote  ----
200      90.90.1.2        0010.9400.0002 Dynamic Remote ----
200      90.90.1.3        9819.2c86.3e01 Static Local   ----
200      90.90.1.4        0010.9400.0005 Dynamic Local  ----
Total number of entries are 8
SH#
SH#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS
```

```
RD[5.5.5.5:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS
SH#
SH#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[2.2.2.2:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[5.5.5.5:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
SH#
SH#sh evpn mpls label esi
S - Self
R - Remote
ESI                            PE-IP-ADDRESS       ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            19
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            19
SH#
SH#sh evpn mpls label alias
S - Self
R - Remote
ESI                            PE-IP-ADDRESS       TENANT             ALIAS-LABEL
================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)           100                 17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)           200                 18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)           100                 17
```

```
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)           200                  18
SH#
SH#sh bgp l2vpn evpn
BGP table version is 6, local router ID is 5.5.5.5
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network         Next Hop          Metric    LocPrf      Weight     Path  Peer
Encap

RD[10:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0        100       0    ?  2.2.2.2         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0        100       0    ?  2.2.2.2         MPLS

RD[20:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     3.3.3.3            0        100       0    ?  3.3.3.3         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     3.3.3.3            0        100       0    ?  3.3.3.3         MPLS

RD[2.2.2.2:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
```

```
                    2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                    2.2.2.2             0        100       0    i  2.2.2.2         MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                    2.2.2.2             0        100       0    i  2.2.2.2         MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[200]:[32,3.3.3.3]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
* i                 2.2.2.2             0        100       0    i  2.2.2.2         MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
* i                 2.2.2.2             0        100       0    i  2.2.2.2         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                    2.2.2.2             0        100       0    i  2.2.2.2         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                    2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>   [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                   5.5.5.5             0        100      32768  i  ----------      MPLS
*>   [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                   5.5.5.5             0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                    3.3.3.3             0        100       0    i  3.3.3.3         MPLS
* i                 2.2.2.2             0        100       0    i  2.2.2.2         MPLS
```

```
*>   [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                   5.5.5.5            0       100      32768  i  ----------     MPLS
* i  [3]:[100]:[32,2.2.2.2]
                    2.2.2.2            0       100       0    i  2.2.2.2        MPLS
* i  [3]:[100]:[32,3.3.3.3]
                    3.3.3.3            0       100       0    i  3.3.3.3        MPLS
*>   [3]:[100]:[32,5.5.5.5]
                   5.5.5.5            0       100      32768  i  ----------     MPLS

RD[5.5.5.5:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                    3.3.3.3            0       100       0    i  3.3.3.3        MPLS
* i                 2.2.2.2            0       100       0    i  2.2.2.2        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    3.3.3.3            0       100       0    i  3.3.3.3        MPLS
* i                 2.2.2.2            0       100       0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                    2.2.2.2            0       100       0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                    2.2.2.2            0       100       0    i  2.2.2.2        MPLS
*>   [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                   5.5.5.5            0       100      32768  i  ----------     MPLS
*>   [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                   5.5.5.5            0       100      32768  i  ----------     MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                    3.3.3.3            0       100       0    i  3.3.3.3        MPLS
* i                 2.2.2.2            0       100       0    i  2.2.2.2        MPLS
*>   [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                   5.5.5.5            0       100      32768  i  ----------     MPLS
* i  [3]:[200]:[32,2.2.2.2]
                    2.2.2.2            0       100       0    i  2.2.2.2        MPLS
* i  [3]:[200]:[32,3.3.3.3]
                    3.3.3.3            0       100       0    i  3.3.3.3        MPLS
*>   [3]:[200]:[32,5.5.5.5]
                   5.5.5.5            0       100      32768  i  ----------     MPLS

Total number of prefixes 46
SH#
SH#sh bgp l2vpn evpn prefix-route

RD[10:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0              0       24               80.80.1.0       0.0.0.0         16
2.2.2.2         MPLS      e8c5:7a88:1738
0              0       24               90.90.1.0       0.0.0.0         16
2.2.2.2         MPLS      e8c5:7a88:1738

RD[20:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
```

```
0               0       24                80.80.1.0       0.0.0.0         16
3.3.3.3         MPLS      e8c5:7ad2:5d98
0               0       24                90.90.1.0       0.0.0.0         16
3.3.3.3         MPLS      e8c5:7ad2:5d98
SH#
SH#sh bgp l2vpn evpn summary
BGP router identifier 5.5.5.5, local AS number 65010
BGP table version is 6
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
2.2.2.2                4 65010  198       189      5      0      0  01:15:56
14      3      6      2      1      2
3.3.3.3                4 65010  203       191      5      0      0  01:15:55
10      3      2      2      1      2

Total number of neighbors 2

Total number of Established sessions 2
SH#
SH#sh ip bgp vrf evpn_anycast
BGP table version is 1, local router ID is 90.90.1.3
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path
*>   80.80.1.0/24     0.0.0.0              0        100       32768  ?
* i                   3.3.3.3              0        100       0    ?
* i                   2.2.2.2              0        100       0    ?
*>   90.90.1.0/24     0.0.0.0              0        100       32768  ?
* i                   3.3.3.3              0        100       0    ?
* i                   2.2.2.2              0        100       0    ?

Total number of prefixes 2
SH#
SH#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          1          3
                                    2         -          Yes   LSP_DEFAULT  25604
xe6         No    30.30.30.2
   L>   3.3.3.3/32          2          6
```

```
                                    5         -          Yes   LSP_DEFAULT  25605
xe6         No    30.30.30.2
   L>   4.4.4.4/32          3         9
                                    8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   10.10.10.0/24       4         9
                                    8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   20.20.20.0/24       5         9
                                    8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
SH#
SH#sh ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2                   xe6        Active    OPERATIONAL   30    01:15:46
3.3.3.3                   xe6        Active    OPERATIONAL   30    01:15:44
4.4.4.4                   xe6        Active    OPERATIONAL   30    01:15:51
SH#
SH#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:33   30.30.30.2     xe6                 0
SH#
SH#sh nvo vxlan l3vni-map
 L3VNI        L2VNI        IRB-interface
===================================
 10000        100          irb100
 10000        200          irb200

SH#
```

P1

```
P1#sh ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
3.3.3.3                   xe1        Active    OPERATIONAL   30    01:21:33
2.2.2.2                   xe4.1      Active    OPERATIONAL   30    01:21:35
5.5.5.5                   xe6        Passive   OPERATIONAL   30    01:19:55
P1#
P1#sh ip ospf neighbor

Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/Backup      00:00:37    10.10.10.1      xe4.1
0
3.3.3.3          1   Full/Backup      00:00:35    20.20.20.1      xe1                 0
5.5.5.5          1   Full/Backup      00:00:35    30.30.30.1      xe6                 0
```

```
P1#
P1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

      Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-
Label     Out-Intf     ELC    Nexthop
         L>   2.2.2.2/32          1          2
                                       1         -          Yes   LSP_DEFAULT  3
xe4.1        No    10.10.10.1
         L>   3.3.3.3/32          2          4
                                       3         -          Yes   LSP_DEFAULT  3
xe1          No    20.20.20.1
         L>   5.5.5.5/32          3          8
                                       7         -          Yes   LSP_DEFAULT  3
xe6          No    30.30.30.1
P1#
```

EVPN MPLS IRB Asymmetric Anycast mode

Topology:

Refer Figure 2-4 depicts the EVPN MPLS IRB with LDP as underlay MPLS path.

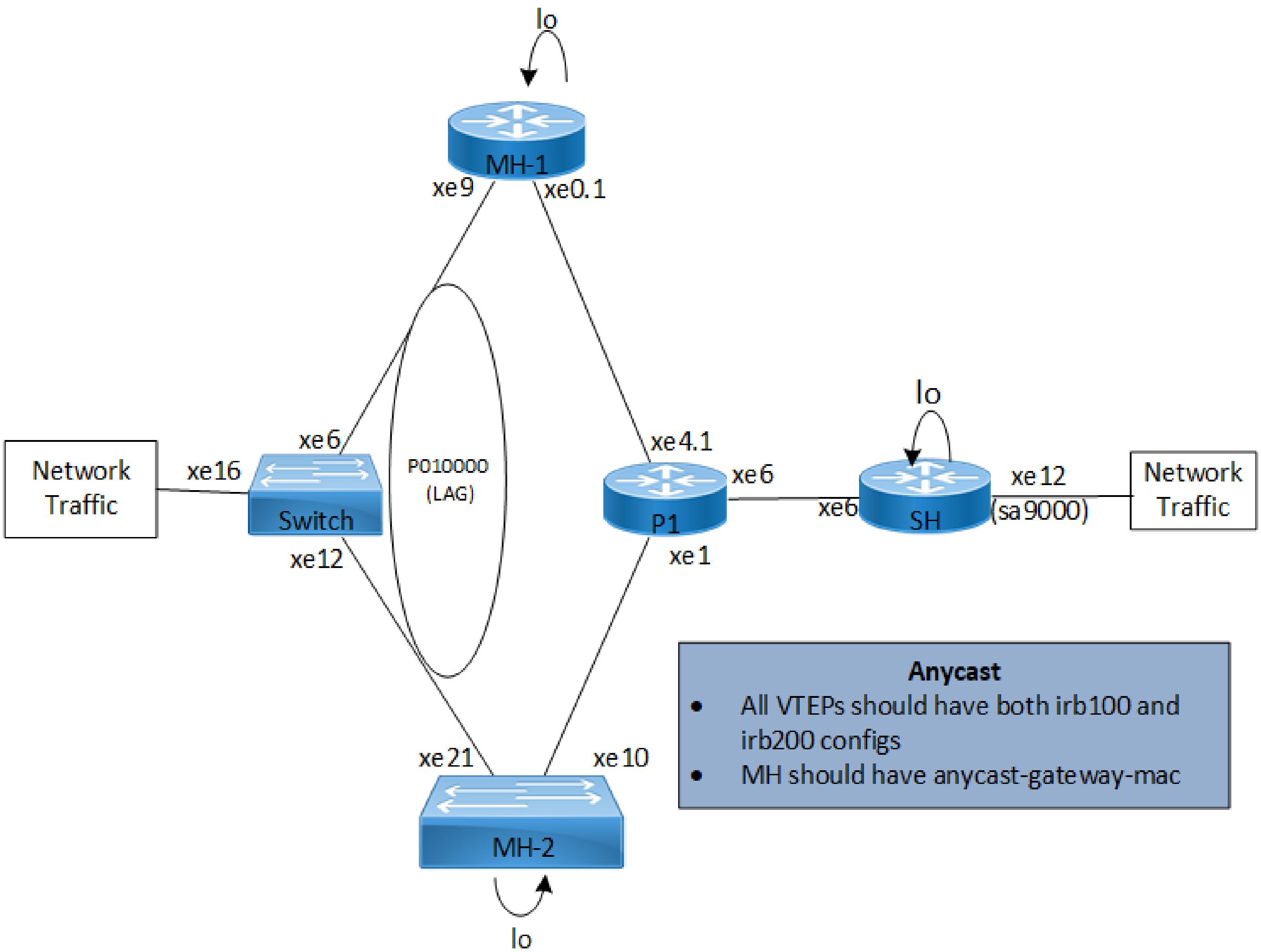

Figure 2-4: EVPN MPLS IRB Asymmetric Anycast mode

Configuration

SH

Enable EVPN MPLS and IRB:

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS globally
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB globally

Loopback Interface:

`(config-if)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)# ip address 5.5.5.5/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

Configure MAC VRF:

`(config)#mac vrf red`	Create MAC VRF red.
`(config-vrf)# rd 5.5.5.5:100`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto route target (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode
`(config)#mac vrf blue`	Create MAC VRF blue.
`(config-vrf)# rd 5.5.5.5:200`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto route target (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode

Configure IP VRF:

`(config)#ip vrf evpn_anycast`	Configure IP VRF evpn.
`(config-vrf)# rd 30:200`	Configure route distinguisher
`(config-vrf)# route-target both 100:200`	Configure route target
`(config-vrf)# l3vni 10000`	Configure L3 VNID for routing
`(config-vrf)#exit`	Exit VRF mode

Configuring IRB interface:

`(config)#interface irb100`	Create IRB interface irb100
`(config-irb-if)# ip vrf forwarding evpn_anycast`	Map L3 VRF to the IRB interface
`(config-irb-if)# ip address 80.80.1.3/24 anycast`	Assign IP address
`(config-irb-if)#exit`	Exit interface mode
`(config)#interface irb200`	Create IRB interface irb100
`(config-irb-if)# ip vrf forwarding evpn_anycast`	Map L3 VRF to the IRB interface

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(config-irb-if)# ip address 90.90.1.3/24 anycast	Assign IP address
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 5.5.5.5	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 5.5.5.5	Enter LDP router-id
(config-router)# transport-address ipv4 5.5.5.5	Configure LDP transport address
(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe6	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 30.30.30.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router id
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

BGP Configuration:

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn_anycast	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config-if)#interface sa9000	Creating Static LAG interface
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)#exit	Exiting out of interface mode
(config-if)#interface sa9000.100 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 100	Map VPN-ID 100
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface sa9000.200 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 200	Map VPN-ID 200
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface xe12	Enter the Interface mode
(config-if)# static-channel-group 9000	Map the physical interface xe12 as static LAG member
(config-if)#exit	Exit interface mode

P1:

Loopback Interface:

#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 4.4.4.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 4.4.4.4	Configure router id
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address
(config-router)#exit	Exit from LDP mode

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Interface Configuration:

(config-if)#interface xe4	Enter the Interface mode for xe4.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Enable LDP on the physical interface
(config)#interface xe4.1	Create sub-interface xe4.1.
(config-if)# description connected-to-MH-1	Configure Interface description
(config-if)# ip address 10.10.10.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter into Interface mode
(config-if)# description connected to MH-2	Configure Interface description
(config-if)# ip address 20.20.20.2/24	Cofigure IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter into Interface mode
(config-if)# description connected to SH	Configure Interface description
(config-if)# ip address 30.30.30.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 4.4.4.4	Setting the Router ID as Loopback IP
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.

(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

MH-1:

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 2.2.2.2/32 secondarysss	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 2.2.2.2:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 2.2.2.2:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF:

`(config)#ip vrf evpn_anycast`	Configure IP VRF evpn.
`(config-vrf)# rd 10:200`	Configure route distinguisher
`(config-vrf)# route-target both 100:200`	Configure route target
`(config-vrf)# l3vni 10000`	Configure L3 VNID for routing
`(config-vrf)#exit`	Exit VRF mode

Configure Anycast Gateway MAC:

`(config)#evpn irb-forwarding anycast-gateway- mac 0011.2233.4455`	Configure anycast gateway MAC globally
`(config)#interface irb100`	Create IRB interface irb100
`(config-irb-if)# ip vrf forwarding evpn`	Map L3 VRF to the IRB interface
`(config-irb-if)# ip address 80.80.1.1/24 anycast`	Assign IP address
`(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac`	Map anycast gateway MAC
`(config-irb-if)#exit`	Exit interface mode
`(config)#interface irb200`	Create IRB interface irb200
`(config-irb-if)# ip vrf forwarding evpn`	Map L3 VRF to the IRB interface
`(config-irb-if)# ip address 90.90.1.1/24 anycast`	Assign IP address
`(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac`	Map anycast gateway MAC
`(config-irb-if)#exit`	Exit interface mode

Creating EVPN MPLS ID:

`(config)#evpn mpls vtep-ip-global 2.2.2.2`	Configure VTEP global IP
`(config)#evpn mpls id 100`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red`	Map the MAC VRF red
`(config-evpn-mpls)# evpn irb irb100`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode
`(config)#evpn mpls id 200`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue`	Map the MAC VRF blue
`(config-evpn-mpls)# evpn irb irb200`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

Global LDP:

`(config)#router ldp`	Enter the Router LDP mode
`(config-router)#router-id 2.2.2.2`	Enter LDP router-id
`(config-router)# transport-address ipv4 2.2.2.2`	Configure LDP transport address
`(config-router)# targeted-peer ipv4 5.5.5.5`	Configure LDP target peer address (SH)
`(config-router-targeted-peer)#exit`	Exit from LDP target peer mode
`(config-router)#exit`	Exit from LDP mode

Interface Configuration Network Side:

`(config-if)#interface xe0`	Enter the Interface mode for xe0.
`(config-if)# mtu 9216`	Configure MTU.
`(config-if)#exit`	Exit from interface xe0
`(config)#interface xe0.1`	Create subinterface in xe10
`(config-if)# encapsulation dot1q 20`	Configure encapsulation as dotq
`(config-if)# ip address 10.10.10.1/24`	Assign IP address
`(config-if)# mtu 9216`	Configure MTU to the sub-if
`(config-if)# label-switching`	Enable label switching
`(config-if)# mpls ldp-igp sync ospf`	Enable LDP IGP sync
`(config-if)# enable-ldp ipv4`	Enable LDP IPv4

OSPF Configuration:

`(config)#router ospf 1`	Enter the Router OSPF mode.
`(config-router)# ospf router-id 2.2.2.2`	Router-ID configurations
`(config-router)# network 2.2.2.2/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`(config-router)# network 10.10.10.0/24 area 0.0.0.0`	Advertise network address in OSPF.

BGP Configuration:

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)#interface xe9	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe9 as LAG member po10000
(config-if)#exit	Exit from interface xe9
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe9
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config)#interface po10000.200 switchport	Creating L2 sub interface of physical interface xe9

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(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 200	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

MH-2:

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 3.3.3.3:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 3.3.3.3:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF:

(config)#ip vrf evpn_anycast	Configure IP VRF evpn.
(config-vrf)# rd 20:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 10000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC:

(config)#evpn irb-forwarding anycastgateway-mac 0011.2233.4455	Configure anycast gateway MAC globally

Configuring IRB interface:

(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode
(config)#interface irb200	Create IRB interface irb200
(config-irb-if)# ip vrf forwarding evpn	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 90.90.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

`(config)#evpn mpls vtep-ip-global 3.3.3.3`	Configure VTEP global IP
`(config)#evpn mpls id 100`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red`	Map the MAC VRF red
`(config-evpn-mpls)# evpn irb irb100`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode
`(config)#evpn mpls id 200`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue`	Map the MAC VRF blue
`(config-evpn-mpls)# evpn irb irb200`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

Global LDP:

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)# transport-address ipv4 3.3.3.3`	Configure LDP transport address
`(config-router)# targeted-peer ipv4 5.5.5.5`	Configure LDP target peer address (SH)
`(config-router-targeted-peer)#exit`	Exit from LDP target peer mode
`(config-router)#exit`	Exit from LDP mode

Interface Configuration Network Side:

`(config-if)#interface xe10`	Enter the configuration mode.
`(config-if)# description connected to P1`	Configure Interface description
`(config-if)# ip address 20.20.20.1/24`	Assign IP address
`(config-if)# mtu 9216`	Configure MTU to the sub-if
`(config-if)# label-switching`	Enable label switching
`(config-if)# mpls ldp-igp sync ospf`	Enable LDP IGP sync
`(config-if)# enable-ldp ipv4`	Enable LDP IPv4
`(config-if)#exit`	Exit interface mode

OSPF Configuration:

`(config)#router ospf 1`	Enter the Router OSPF mode.
`(config-router)# ospf router-id 3.3.3.3`	Router-ID configurations
`(config-router)# network 3.3.3.3/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`(config-router)# network 20.20.20.0/24 area 0.0.0.0`	Advertise network address in OSPF.

BGP Configuration:

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn_anycast	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)#interface xe21	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe21 as LAG member po10000
(config-if)#exit	Exit from interface xe21
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config)#interface po10000.200 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 200	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

Note: Remote entries cannot be fetched from through MAC table/ARP cache/ND cache. However they can be fetched from the BGP table.

MH-1:

```
MH-1#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr          Dst-Addr

________________________________________________________________________________________
________________________________________
```

```
100      ----         L2         NW   ----      ----                         ----      -
---      2.2.2.2         3.3.3.3
100      ----         L2         NW   ----      ----                         ----      -
---      2.2.2.2         5.5.5.5
100     ----       --      AC   po10000.100 00:00:00:11:11:aa:aa:00:00:00 ----    DF
----            ----
200      ----         L2         NW   ----      ----                         ----      -
---      2.2.2.2         3.3.3.3
200      ----         L2         NW   ----      ----                         ----      -
---      2.2.2.2         5.5.5.5
200     ----       --      AC   po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----    DF
----            ----
10000    ----         L3         NW   ----      ----                         ----      -
---      2.2.2.2         3.3.3.3
10000    ----         L3         NW   ----      ----                         ----      -
---      2.2.2.2         5.5.5.5

Total number of entries are 8
MH-1#
MH-1#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=====================================================================================
2.2.2.2          3.3.3.3          Installed     01:16:34      01:16:34      200
2.2.2.2          3.3.3.3          Installed     01:16:34      01:16:34      100
2.2.2.2          3.3.3.3          Installed     01:23:48      01:23:48      10000
2.2.2.2          5.5.5.5          Installed     01:14:59      01:14:59      200
2.2.2.2          5.5.5.5          Installed     01:14:59      01:14:59      100
2.2.2.2          5.5.5.5          Installed     01:23:48      01:23:48      10000

Total number of entries are 6
MH-1#
MH-1#sh evpn mpls mac-table
=========================================================================================
===================================================
                                                     EVPN MPLS MAC Entries
=========================================================================================
===================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
_________________________________________________________________________________________
___________________________________________________

100        irb100    ----       ----      0011.2233.4455 2.2.2.2
Static Local    -------    0        -------
100        ----      ----       ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0        -------
100       po10000.100 ----       ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Local   -------    0        -------
100        ----      ----       ----      0010.9400.0004 5.5.5.5
Dynamic Remote  -------    0        -------
200        irb200    ----       ----      0011.2233.4455 2.2.2.2
Static Local    -------    0        -------
```

```
200        ----       ----       ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0         -------
200       po10000.200 ----      ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Local   -------    0         -------
200        ----       ----       ----      0010.9400.0005 5.5.5.5
Dynamic Remote  -------    0         -------

Total number of entries are : 8

MH-1#
MH-1#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.1        0011.2233.4455 Static Local   ----
100      80.80.1.2        0010.9400.0001 Dynamic Local  244      2
100      80.80.1.3        9819.2c86.3e01 Static Remote  ----
100      80.80.1.4        0010.9400.0004 Dynamic Remote ----
200      90.90.1.1        0011.2233.4455 Static Local   ----
200      90.90.1.2        0010.9400.0002 Dynamic Local  ----
200      90.90.1.3        9819.2c86.3e01 Static Remote  ----
200      90.90.1.4        0010.9400.0005 Dynamic Remote ----
Total number of entries are 8
MH-1#
MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS

RD[2.2.2.2:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS
MH-1#
MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
```

```
RD[2.2.2.2:200] VRF[blue]:
ESI                          Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100]
ESI                          Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200]
ESI                          Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
MH-1#
MH-1#sh evpn mpls label esi
S - Self
R - Remote
ESI                          PE-IP-ADDRESS        ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)            19
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            19
MH-1#
MH-1#sh evpn mpls label alias
S - Self
R - Remote
ESI                          PE-IP-ADDRESS        TENANT              ALIAS-LABEL
=====================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)           100                  17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)           200                  18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)           100                  17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)           200                  18
MH-1#
MH-1#sh bgp l2vpn evpn
BGP table version is 10, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network        Next Hop          Metric    LocPrf      Weight     Path  Peer
Encap

RD[20:200]
```

```
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     3.3.3.3            0        100       0    ?  3.3.3.3         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     3.3.3.3            0        100       0    ?  3.3.3.3         MPLS

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     5.5.5.5            0        100       0    ?  5.5.5.5         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     5.5.5.5            0        100       0    ?  5.5.5.5         MPLS

RD[2.2.2.2:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>                  2.2.2.2            0        100      32768  i  ----------      MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                    2.2.2.2            0        100      32768  i  ----------      MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                    2.2.2.2            0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                     5.5.5.5            0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                     5.5.5.5            0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                     3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>                  2.2.2.2            0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                     5.5.5.5            0        100       0    i  5.5.5.5         MPLS
*>   [3]:[100]:[32,2.2.2.2]
                    2.2.2.2            0        100      32768  i  ----------      MPLS
* i  [3]:[100]:[32,3.3.3.3]
                     3.3.3.3            0        100       0    i  3.3.3.3         MPLS
* i  [3]:[100]:[32,5.5.5.5]
                     5.5.5.5            0        100       0    i  5.5.5.5         MPLS

RD[2.2.2.2:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>                  2.2.2.2            0        100      32768  i  ----------      MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                    2.2.2.2            0        100      32768  i  ----------      MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                    2.2.2.2            0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                     5.5.5.5            0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
```

```
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>                  2.2.2.2             0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>   [3]:[200]:[32,2.2.2.2]
                    2.2.2.2             0        100      32768  i  ----------      MPLS
* i  [3]:[200]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
* i  [3]:[200]:[32,5.5.5.5]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    2.2.2.2             0        100      32768  i  ----------      MPLS
*>   [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                    2.2.2.2             0        100      32768  i  ----------      MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[200]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[5.5.5.5:100]
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
```

```
*>i  [3]:[100]:[32,5.5.5.5]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS

Total number of prefixes 45
MH-1#
MH-1#sh bgp l2vpn evpn prefix-route

RD[20:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0              0       24               80.80.1.0       0.0.0.0         16
3.3.3.3         MPLS      e8c5:7ad2:5d98
0              0       24               90.90.1.0       0.0.0.0         16
3.3.3.3         MPLS      e8c5:7ad2:5d98

RD[30:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0              0       24               80.80.1.0       0.0.0.0         16
5.5.5.5         MPLS      9819:2c86:3e01
0              0       24               90.90.1.0       0.0.0.0         16
5.5.5.5         MPLS      9819:2c86:3e01
MH-1#
MH-1#sh bgp l2vpn evpn summary
BGP router identifier 2.2.2.2, local AS number 65010
BGP table version is 10
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
3.3.3.3                  4 65010  205        203      9      0      0  01:17:25
10      3      2      2      1      2
5.5.5.5                  4 65010  187        197      9      0      0  01:15:01
10      0      6      2      0      2

Total number of neighbors 2

Total number of Established sessions 2
MH-1#
MH-1#sh ip bgp vrf evpn_anycast
BGP table version is 1, local router ID is 90.90.1.1
```

```
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path
*>   80.80.1.0/24     0.0.0.0              0         100       32768  ?
* i                   5.5.5.5              0         100       0    ?
* i                   3.3.3.3              0         100       0    ?
*>   90.90.1.0/24     0.0.0.0              0         100       32768  ?
* i                   5.5.5.5              0         100       0    ?
* i                   3.3.3.3              0         100       0    ?

Total number of prefixes 2
MH-1#
MH-1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   3.3.3.3/32         1         3
                                    2         -          Yes   LSP_DEFAULT  25600
xe0.1       No    10.10.10.2
   L>   4.4.4.4/32         2         6
                                    5         -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
   L>   5.5.5.5/32         5         8
                                    7         -          Yes   LSP_DEFAULT  25603
xe0.1       No    10.10.10.2
   L>   20.20.20.0/24      3         6
                                    5         -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
   L>   30.30.30.0/24      4         6
                                    5         -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
MH-1#
MH-1#sh ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                   xe0.1      Passive   OPERATIONAL   30    01:14:50
4.4.4.4                   xe0.1      Passive   OPERATIONAL   30    01:16:35
MH-1#
MH-1#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:39   10.10.10.2     xe0.1                 0
```

```
MH-1#
MH-1#sh nvo vxlan l3vni-map
 L3VNI        L2VNI        IRB-interface
===================================
 10000        100          irb100
 10000        200          irb200

MH-1#
```

MH-2:

```
MH-2#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
_______________________________________________________________________________________
________________________________________
100      ----         L2        NW   ----      ----                         ----      -
---      3.3.3.3          5.5.5.5
100      ----         L2        NW   ----      ----                         ----      -
---      3.3.3.3          2.2.2.2
100      ----         --        AC   po10000.100 00:00:00:11:11:aa:aa:00:00:00 ----
NON-DF    ----            ----
200      ----         L2        NW   ----      ----                         ----      -
---      3.3.3.3          5.5.5.5
200      ----         L2        NW   ----      ----                         ----      -
---      3.3.3.3          2.2.2.2
200      ----         --        AC   po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----
NON-DF    ----            ----
10000    ----         L3        NW   ----      ----                         ----      -
---      3.3.3.3          5.5.5.5
10000    ----         L3        NW   ----      ----                         ----      -
---      3.3.3.3          2.2.2.2

Total number of entries are 8
MH-2#
MH-2#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
===============================================================================
3.3.3.3          5.5.5.5          Installed     01:15:41      01:15:41      200
3.3.3.3          5.5.5.5          Installed     01:15:41      01:15:41      100
3.3.3.3          5.5.5.5          Installed     01:24:08      01:24:08      10000
3.3.3.3          2.2.2.2          Installed     01:17:15      01:17:15      200
3.3.3.3          2.2.2.2          Installed     01:17:15      01:17:15      100
3.3.3.3          2.2.2.2          Installed     01:24:08      01:24:08      10000
```

```
Total number of entries are 6
MH-2#
MH-2#sh evpn mpls mac-table
==========================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
==========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI              Type
Status     MAC move AccessPortDesc
__________________________________________________________________________________________
__________________________________________________

100        irb100    ----       ----      0011.2233.4455 3.3.3.3
Static Local    -------    0        -------
100        ----      ----       ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0        -------
100        ----      ----       ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
100        ----      ----       ----      0010.9400.0004 5.5.5.5
Dynamic Remote  -------    0        -------
200        irb200    ----       ----      0011.2233.4455 3.3.3.3
Static Local    -------    0        -------
200        ----      ----       ----      9819.2c86.3e01 5.5.5.5
Static Remote   -------    0        -------
200        ----      ----       ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
200        ----      ----       ----      0010.9400.0005 5.5.5.5
Dynamic Remote  -------    0        -------

Total number of entries are : 8

MH-2#
MH-2#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.1        0011.2233.4455 Static Local   ----
100      80.80.1.2        0010.9400.0001 Dynamic Remote ----
100      80.80.1.3        9819.2c86.3e01 Static Remote  ----
100      80.80.1.4        0010.9400.0004 Dynamic Remote ----
200      90.90.1.1        0011.2233.4455 Static Local   ----
200      90.90.1.2        0010.9400.0002 Dynamic Remote ----
200      90.90.1.3        9819.2c86.3e01 Static Remote  ----
200      90.90.1.4        0010.9400.0005 Dynamic Remote ----
Total number of entries are 8
MH-2#
MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es
```

```
RD[2.2.2.2:64512]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:100] VRF[red]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:200] VRF[blue]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS
MH-2#
MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[2.2.2.2:200]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100] VRF[red]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200] VRF[blue]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
MH-2#
MH-2#sh evpn mpls label esi
S - Self
R - Remote
ESI                             PE-IP-ADDRESS        ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)             19
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)             19
MH-2#
MH-2#sh evpn mpls label alias
S - Self
R - Remote
ESI                             PE-IP-ADDRESS        TENANT               ALIAS-LABEL
=====================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            100                   17
```

```
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)           200                   18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)           100                   17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)           200                   18
MH-2#
MH-2#sh bgp l2vpn evpn
BGP table version is 16, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network         Next Hop          Metric    LocPrf      Weight     Path  Peer
Encap

RD[10:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0       100       0    ?  2.2.2.2         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0       100       0    ?  2.2.2.2         MPLS

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     5.5.5.5            0       100       0    ?  5.5.5.5         MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     5.5.5.5            0       100       0    ?  5.5.5.5         MPLS

RD[2.2.2.2:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0       100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     2.2.2.2            0       100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     2.2.2.2            0       100       0    i  2.2.2.2         MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                     2.2.2.2            0       100       0    i  2.2.2.2         MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                     2.2.2.2            0       100       0    i  2.2.2.2         MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2            0       100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                     2.2.2.2            0       100       0    i  2.2.2.2         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
```

```
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[3.3.3.3:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>                  3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>                  3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [3]:[100]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>   [3]:[100]:[32,3.3.3.3]
                    3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [3]:[100]:[32,5.5.5.5]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS

RD[3.3.3.3:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>                  3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
```

```
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                    2.2.2.2           0        100       0    i  2.2.2.2        MPLS
*>                 3.3.3.3           0        100      32768  i  ----------     MPLS
* i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
* i  [3]:[200]:[32,2.2.2.2]
                    2.2.2.2           0        100       0    i  2.2.2.2        MPLS
*>   [3]:[200]:[32,3.3.3.3]
                   3.3.3.3           0        100      32768  i  ----------     MPLS
* i  [3]:[200]:[32,5.5.5.5]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                   3.3.3.3           0        100      32768  i  ----------     MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                    2.2.2.2           0        100       0    i  2.2.2.2        MPLS
*>   [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                   3.3.3.3           0        100      32768  i  ----------     MPLS

RD[5.5.5.5:100]
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
*>i  [3]:[100]:[32,5.5.5.5]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                    5.5.5.5           0        100       0    i  5.5.5.5        MPLS

Total number of prefixes 49
MH-2#
MH-2#sh bgp l2vpn evpn prefix-route

RD[10:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0               0       24              80.80.1.0       0.0.0.0         16
2.2.2.2         MPLS      e8c5:7a88:1738
```

```
0              0       24                90.90.1.0       0.0.0.0         16
2.2.2.2         MPLS      e8c5:7a88:1738

RD[30:200]
ESI             Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop          Encap     Router-Mac
0              0       24                80.80.1.0       0.0.0.0         16
5.5.5.5         MPLS      9819:2c86:3e01
0              0       24                90.90.1.0       0.0.0.0         16
5.5.5.5         MPLS      9819:2c86:3e01
MH-2#
MH-2#sh bgp l2vpn evpn summary
BGP router identifier 3.3.3.3, local AS number 65010
BGP table version is 16
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
2.2.2.2                4 65010  203       207     16      0      0  01:18:08
14      3      6      2      1      2
5.5.5.5                4 65010  190       202     16      0      0  01:15:43
10      0      6      2      0      2

Total number of neighbors 2

Total number of Established sessions 2
MH-2#
MH-2#sh ip bgp vrf evpn_anycast
BGP table version is 1, local router ID is 90.90.1.1
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path
*>   80.80.1.0/24     0.0.0.0              0        100       32768  ?
* i                   5.5.5.5              0        100       0    ?
* i                   2.2.2.2              0        100       0    ?
*>   90.90.1.0/24     0.0.0.0              0        100       32768  ?
* i                   5.5.5.5              0        100       0    ?
* i                   2.2.2.2              0        100       0    ?

Total number of prefixes 2
MH-2#
MH-2#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP
```

```
Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          1         3
                                    2         -           Yes   LSP_DEFAULT  25601
xe10        No    20.20.20.2
   L>   4.4.4.4/32          2         6
                                    5         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
   L>   5.5.5.5/32          5         8
                                    7         -           Yes   LSP_DEFAULT  25602
xe10        No    20.20.20.2
   L>   10.10.10.0/24       3         6
                                    5         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
   L>   30.30.30.0/24       4         6
                                    5         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
MH-2#
MH-2#sh ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
5.5.5.5                   xe10       Passive   OPERATIONAL   30    01:15:31
4.4.4.4                   xe10       Passive   OPERATIONAL   30    01:17:16
MH-2#
MH-2#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:33   20.20.20.2      xe10                  0
MH-2#
MH-2#sh nvo vxlan l3vni-map
 L3VNI        L2VNI        IRB-interface
===================================
 10000        100          irb100
 10000        200          irb200

MH-2#
```

SH:

```
SH#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
________________________________________________________________________________________
________________________________________
```

```
100      ----         L2         NW   ----      ----                         ----      -
---      5.5.5.5          2.2.2.2
100      ----         L2         NW   ----      ----                         ----      -
---      5.5.5.5          3.3.3.3
100      ----         --        AC   sa9000.100 --- Single Homed Port ---     ----      -
---      ----             ----
200      ----         L2         NW   ----      ----                         ----      -
---      5.5.5.5          2.2.2.2
200      ----         L2         NW   ----      ----                         ----      -
---      5.5.5.5          3.3.3.3
200      ----         --        AC   sa9000.200 --- Single Homed Port ---     ----      -
---      ----             ----
10000    ----         L3         NW   ----      ----                         ----      -
---      5.5.5.5          2.2.2.2
10000    ----         L3         NW   ----      ----                         ----      -
---      5.5.5.5          3.3.3.3

Total number of entries are 8
SH#
SH#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
==================================================================================
5.5.5.5          2.2.2.2          Installed     01:15:49      01:15:49      200
5.5.5.5          2.2.2.2          Installed     01:15:49      01:15:49      100
5.5.5.5          2.2.2.2          Installed     01:25:33      01:25:33      10000
5.5.5.5          3.3.3.3          Installed     01:15:49      01:15:49      200
5.5.5.5          3.3.3.3          Installed     01:15:49      01:15:49      100
5.5.5.5          3.3.3.3          Installed     01:25:33      01:25:33      10000

Total number of entries are 6
SH#
SH#sh evpn mpls mac-table
=========================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
=========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI              Type
Status     MAC move AccessPortDesc
_________________________________________________________________________________________
__________________________________________________

100        ----       ----       ----      0011.2233.4455 2.2.2.2
Static Remote   -------    0        -------
100        irb100     ----       ----      9819.2c86.3e01 5.5.5.5
Static Local    -------    0        -------
100        ----       ----       ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
100        sa9000.100 ----       ----      0010.9400.0004 5.5.5.5
Dynamic Local   -------    0        -------
200        ----       ----       ----      0011.2233.4455 2.2.2.2
Static Remote   -------    0        -------
```

```
200        irb200    ----      ----      9819.2c86.3e01 5.5.5.5
Static Local    -------    0        -------
200        ----      ----      ----      0010.9400.0002 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
200        sa9000.200 ----      ----      0010.9400.0005 5.5.5.5
Dynamic Local   -------    0        -------

Total number of entries are : 8

SH#
SH#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.1        0011.2233.4455 Static Remote  ----
100      80.80.1.2        0010.9400.0001 Dynamic Remote ----
100      80.80.1.3        9819.2c86.3e01 Static Local   ----
100      80.80.1.4        0010.9400.0004 Dynamic Local  ----
200      90.90.1.1        0011.2233.4455 Static Remote  ----
200      90.90.1.2        0010.9400.0002 Dynamic Remote ----
200      90.90.1.3        9819.2c86.3e01 Static Local   ----
200      90.90.1.4        0010.9400.0005 Dynamic Local  ----
Total number of entries are 8
SH#
SH#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[3.3.3.3:64512]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS

RD[5.5.5.5:200] VRF[blue]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  19             2.2.2.2         MPLS
SH#
SH#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
```

```
RD[2.2.2.2:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[5.5.5.5:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
SH#
SH#sh evpn mpls label esi
S - Self
R - Remote
ESI                            PE-IP-ADDRESS       ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            19
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            19
SH#
SH#sh evpn mpls label alias
S - Self
R - Remote
ESI                            PE-IP-ADDRESS       TENANT               ALIAS-LABEL
=======================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)           100                   17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)           200                   18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)           100                   17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)           200                   18
SH#
SH#sh bgp l2vpn evpn
BGP table version is 6, local router ID is 5.5.5.5
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
```

```
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network         Next Hop           Metric    LocPrf      Weight     Path  Peer
Encap

RD[10:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0        100       0    ?  2.2.2.2        MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     2.2.2.2            0        100       0    ?  2.2.2.2        MPLS

RD[20:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     3.3.3.3            0        100       0    ?  3.3.3.3        MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     3.3.3.3            0        100       0    ?  3.3.3.3        MPLS

RD[2.2.2.2:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
```

```
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[200]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
* i                 2.2.2.2            0        100       0    i  2.2.2.2         MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
* i                 2.2.2.2            0        100       0    i  2.2.2.2         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>   [2]:[0]:[100]:[48,0010:9400:0004]:[0]:[17]
                   5.5.5.5            0        100      32768  i  ----------      MPLS
*>   [2]:[0]:[100]:[48,0010:9400:0004]:[32,80.80.1.4]:[17]
                   5.5.5.5            0        100      32768  i  ----------      MPLS
* i  [2]:[0]:[100]:[48,0011:2233:4455]:[32,80.80.1.1]:[17]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
* i                 2.2.2.2            0        100       0    i  2.2.2.2         MPLS
*>   [2]:[0]:[100]:[48,9819:2c86:3e01]:[32,80.80.1.3]:[17]
                   5.5.5.5            0        100      32768  i  ----------      MPLS
* i  [3]:[100]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2         MPLS
* i  [3]:[100]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
*>   [3]:[100]:[32,5.5.5.5]
                   5.5.5.5            0        100      32768  i  ----------      MPLS

RD[5.5.5.5:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                    3.3.3.3            0        100       0    i  3.3.3.3         MPLS
```

```
* i                   2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                      3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i                   2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[0]:[18]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[48,0010:9400:0002]:[32,90.90.1.2]:[18]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>   [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[18]
                     5.5.5.5            0       100      32768  i  ----------     MPLS
*>   [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[18]
                     5.5.5.5            0       100      32768  i  ----------     MPLS
* i  [2]:[0]:[200]:[48,0011:2233:4455]:[32,90.90.1.1]:[18]
                      3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i                   2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>   [2]:[0]:[200]:[48,9819:2c86:3e01]:[32,90.90.1.3]:[18]
                     5.5.5.5            0       100      32768  i  ----------     MPLS
* i  [3]:[200]:[32,2.2.2.2]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [3]:[200]:[32,3.3.3.3]
                      3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>   [3]:[200]:[32,5.5.5.5]
                     5.5.5.5            0       100      32768  i  ----------     MPLS

Total number of prefixes 46
SH#
SH#sh bgp l2vpn evpn prefix-route

RD[10:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0              0       24               80.80.1.0       0.0.0.0         16
2.2.2.2         MPLS      e8c5:7a88:1738
0              0       24               90.90.1.0       0.0.0.0         16
2.2.2.2         MPLS      e8c5:7a88:1738

RD[20:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0              0       24               80.80.1.0       0.0.0.0         16
3.3.3.3         MPLS      e8c5:7ad2:5d98
0              0       24               90.90.1.0       0.0.0.0         16
3.3.3.3         MPLS      e8c5:7ad2:5d98
SH#
SH#sh bgp l2vpn evpn summary
BGP router identifier 5.5.5.5, local AS number 65010
BGP table version is 6
1 BGP AS-PATH entries
0 BGP community entries

Neighbor              V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
```

```
2.2.2.2             4 65010  198       189      5      0      0  01:15:56
14      3      6      2      1      2
3.3.3.3             4 65010  203       191      5      0      0  01:15:55
10      3      2      2      1      2

Total number of neighbors 2

Total number of Established sessions 2
SH#
SH#sh ip bgp vrf evpn_anycast
BGP table version is 1, local router ID is 90.90.1.3
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path
*>   80.80.1.0/24     0.0.0.0              0        100       32768  ?
* i                   3.3.3.3              0        100       0    ?
* i                   2.2.2.2              0        100       0    ?
*>   90.90.1.0/24     0.0.0.0              0        100       32768  ?
* i                   3.3.3.3              0        100       0    ?
* i                   2.2.2.2              0        100       0    ?

Total number of prefixes 2
SH#
SH#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         3
                                    2         -          Yes   LSP_DEFAULT  25604
xe6         No    30.30.30.2
   L>   3.3.3.3/32         2         6
                                    5         -          Yes   LSP_DEFAULT  25605
xe6         No    30.30.30.2
   L>   4.4.4.4/32         3         9
                                    8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   10.10.10.0/24      4         9
                                    8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   20.20.20.0/24      5         9
                                    8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
SH#
SH#sh ldp session
```

```
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
2.2.2.2                  xe6        Active    OPERATIONAL   30    01:15:46
3.3.3.3                  xe6        Active    OPERATIONAL   30    01:15:44
4.4.4.4                  xe6        Active    OPERATIONAL   30    01:15:51
SH#
SH#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:33    30.30.30.2      xe6                  0
SH#
SH#sh nvo vxlan l3vni-map
 L3VNI        L2VNI        IRB-interface
===================================
 10000        100          irb100
 10000        200          irb200

SH#
```

P1:

```
P1#sh ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
3.3.3.3                  xe1        Active    OPERATIONAL   30    01:21:33
2.2.2.2                  xe4.1      Active    OPERATIONAL   30    01:21:35
5.5.5.5                  xe6        Passive   OPERATIONAL   30    01:19:55
P1#
P1#sh ip ospf neighbor

Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/Backup      00:00:37    10.10.10.1      xe4.1
0
3.3.3.3          1   Full/Backup      00:00:35    20.20.20.1      xe1                  0
5.5.5.5          1   Full/Backup      00:00:35    30.30.30.1      xe6                  0
P1#
P1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          1         2
```

```
                                    1         -           Yes   LSP_DEFAULT  3
xe4.1       No    10.10.10.1
   L>   3.3.3.3/32          2         4
                                    3         -           Yes   LSP_DEFAULT  3
xe1         No    20.20.20.1
   L>   5.5.5.5/32          3         8
                                    7         -           Yes   LSP_DEFAULT  3
xe6         No    30.30.30.1
P1#
```

EVPN MPLS IRB Asymmetric Centralized mode

Topology

Figure 2-5 depicts the EVPN MPLS IRB Asymmetric centralized mode.

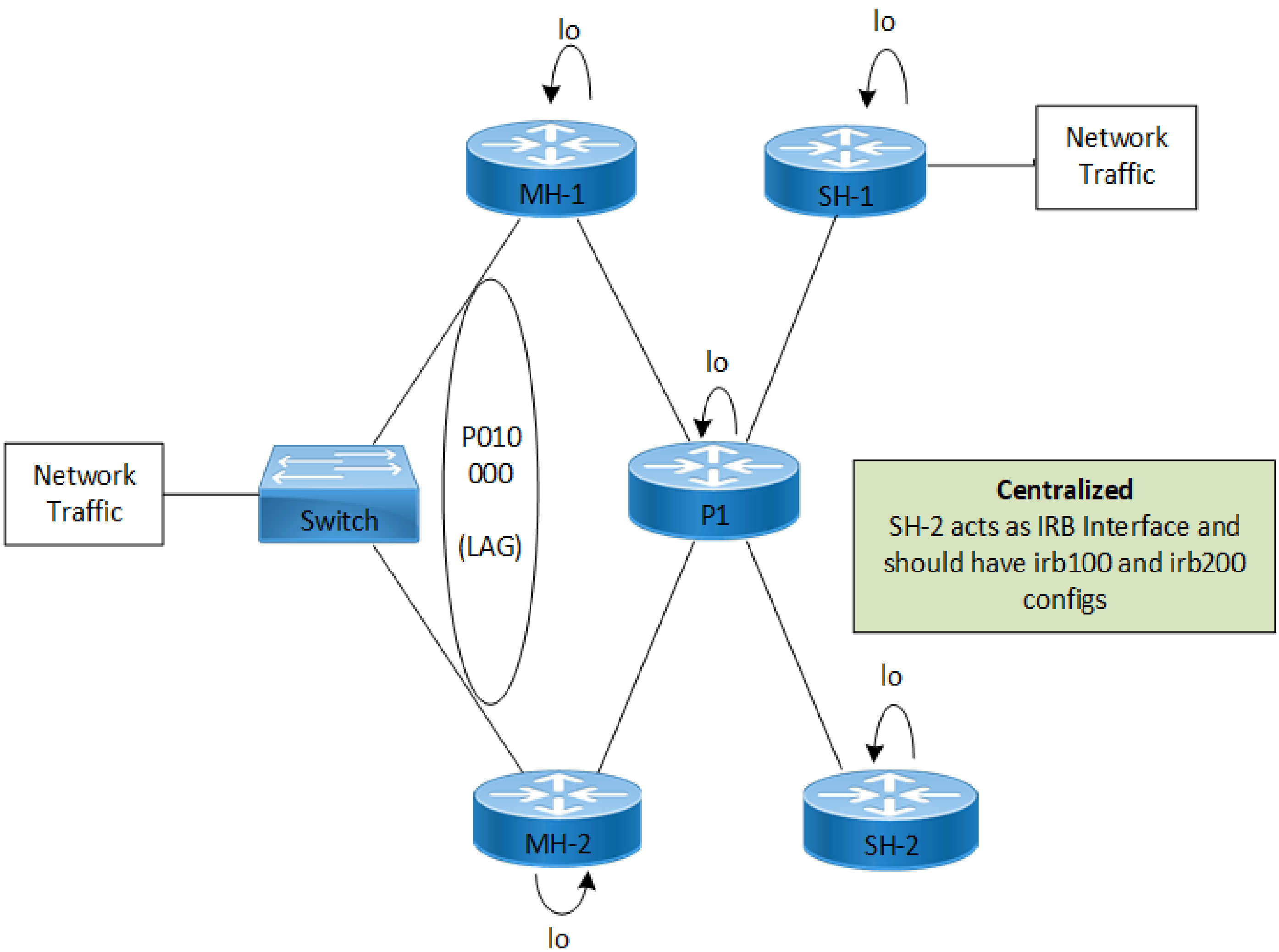

Figure 2-5: EVPN MPLS IRB Centralized Mode

Configurations:

SH-2:

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 6.6.6.6/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 6.6.6.6:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 6.6.6.6:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF:

(config)#ip vrf evpn_anycast	Configure IP VRF evpn.
(config-vrf)# rd 30:200	Configure route distinguisher
(config-vrf)# route-target both 100:200	Configure route target
(config-vrf)# l3vni 10000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configuring IRB interface:

(config)#evpn irb-forwarding anycast-gateway- mac 0077.8899.5566	Configure anycast gateway MAC globally
(config)#interface irb100	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding evpn_anycast	Map L3 VRF to the IRB interface
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)# ip address 80.80.1.3/24 anycast	Assign IP address
(config-irb-if)#exit	Exit interface mode

`(config)#interface irb200`	Create IRB interface irb100
`(config-irb-if)# ip vrf forwarding evpn_anycast`	Map L3 VRF to the IRB interface
`(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac`	Map anycast gateway MAC
`(config-irb-if)# ip address 90.90.1.3/24 anycast`	Assign IP address
`(config-irb-if)#exit`	Exit interface mode

Creating EVPN MPLS ID:

`(config)#evpn mpls vtep-ip-global 6.6.6.6`	Configure VTEP global IP
`(config)#evpn mpls id 100`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachability-protocol evpn-bgp red`	Map the MAC VRF red
`(config-evpn-mpls)# evpn irb irb100`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode
`(config)#evpn mpls id 200`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachability-protocol evpn-bgp blue`	Map the MAC VRF blue
`(config-evpn-mpls)# evpn irb irb200`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 6.6.6.6	Enter LDP router-id
(config-router)# transport-address ipv4 6.6.6.6	Configure LDP transport address
(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe14	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 40.40.40.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 6.6.6.6	Configure OSPF router id
(config-router)# network 6.6.6.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 40.40.40.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

BGP Configuration:

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP

`(config-router)# neighbor 3.3.3.3 update-source lo`	Source of routing updates as loopback
`(config-router)# neighbor 5.5.5.5 remote-as 65010`	Configuring MH-1 as I-BGP neighbor using it's loopback IP
`(config-router)# neighbor 5.5.5.5 update-source lo`	Source of routing updates as loopback
`(config-router-af)# exit-address-family`	Exiting of Address family mode
`(config-router)# address-family l2vpn evpn`	Entering into address family mode as EVPN
`(config-router-af)# neighbor 2.2.2.2 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# neighbor 3.3.3.3 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# neighbor 5.5.5.5 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# exit-address-family`	Exiting of Address family mode
`(config-router)# address-family ipv4 vrf evpn_anycast`	Entering into VRF address family mode
`(config-router-af)# redistribute connected`	Redistribute connected routes to the network
`(config-router-af)# exit-address-family`	Exiting of Address family mode

SH-1:

Enable EVPN MPLS and IRB:

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS globally
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB globally

Loopback Interface:

`(config-if)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)# ip address 5.5.5.5/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

Configure MAC VRF:

`(config)#mac vrf red`	Create MAC VRF red.
`(config-vrf)# rd 5.5.5.5:100`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto route target (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode
`(config)#mac vrf blue`	Create MAC VRF blue.
`(config-vrf)# rd 5.5.5.5:200`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto route target (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode

Creating EVPN MPLS ID:

`(config)#evpn mpls vtep-ip-global 5.5.5.5`	Configure VTEP global IP
`(config)#evpn mpls id 100`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachability-protocol evpn-bgp red`	Map the MAC VRF red
`(config-evpn-mpls)# evpn irb irb100`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode
`(config)#evpn mpls id 200`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachability-protocol evpn-bgp blue`	Map the MAC VRF blue
`(config-evpn-mpls)# evpn irb irb200`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 5.5.5.5	Enter LDP router-id
(config-router)# transport-address ipv4 5.5.5.5	Configure LDP transport address
(config-router)# targeted-peer ipv4 2.2.2.2	Configure LDP target peer address (MH-1)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 3.3.3.3	Configure LDP target peer address (MH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 6.6.6.6	Configure LDP target peer address (SH-2)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe6	Enter interface mode
(config-if)# description connected to P1	Configure interface description
(config-if)# ip address 30.30.30.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router id
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)#exit	Exit OSPF mode

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BGP Configuration:

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring MH-1 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 3.3.3.3 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 3.3.3.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 6.6.6.6 remote-as 65010	Configuring MH-2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 6.6.6.6 update-source lo	Source of routing updates as loopback
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 3.3.3.3 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 6.6.6.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config-if)#interface sa9000	Creating Static LAG interface
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)#exit	Exiting out of interface mode
(config-if)#interface sa9000.100 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 100	Map VPN-ID 100
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface sa9000.200 switchport	Creating Static LAG L2 sub interface of physical interface xe12
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)#map vpn-id 200	Map VPN-ID 200
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config-if)#interface xe12	Enter the Interface mode

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`(config-if)# static-channel-group 9000`	Map the physical interface xe12 as static LAG member
`(config-if)#exit`	Exit interface mode

P1:

Loopback Interface:

#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 4.4.4.4/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 4.4.4.4	Configure router id
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address
(config-router)#exit	Exit from LDP mode

Interface Configuration:

(config-if)#interface xe4	Enter the Interface mode for xe4.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Enable LDP on the physical interface
(config)#interface xe4.1	Create sub-interface xe4.1.
(config-if)# description connected-to-MH-1	Configure Interface description
(config-if)# ip address 10.10.10.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter into Interface mode
(config-if)# description connected to MH-2	Configure Interface description
(config-if)# ip address 20.20.20.2/24	Cofigure IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter into Interface mode
(config-if)# description connected to SH-1	Configure Interface description
(config-if)# ip address 30.30.30.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync

(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe10	Enter into Interface mode
(config-if)# description connected to SH-2	Configure Interface description
(config-if)# ip address 40.40.40.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSFP Configuration

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 4.4.4.4	Setting the Router ID as Loopback IP
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.10.10.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 30.30.30.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)# network 40.40.40.0/24 area 0.0.0.0	Advertise network address in OSPF that comes under same subnet.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

MH-1:

Enable EVPN MPLS and IRB:

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface:

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 2.2.2.2/32 secondarysss	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF:

(config)#mac vrf red	Create MAC VRF red.
(config-vrf)# rd 2.2.2.2:100	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode
(config)#mac vrf blue	Create MAC VRF blue.
(config-vrf)# rd 2.2.2.2:200	Configure route distinguisher
(config-vrf)# route-target both evpn-auto-rt	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC:

(config)#evpn irb-forwarding anycast-gateway- mac 0011.2233.4455	Configure anycast gateway MAC globally

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 2.2.2.2	Configure VTEP global IP
(config)#evpn mpls id 100	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red	Map the MAC VRF red
(config-evpn-mpls)# evpn irb irb100	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode
(config)#evpn mpls id 200	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue	Map the MAC VRF blue
(config-evpn-mpls)# evpn irb irb200	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP:

(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 2.2.2.2	Enter LDP router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 6.6.6.6	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe0	Enter the Interface mode for xe0.
(config-if)# mtu 9216	Configure MTU.
(config-if)#exit	Exit from interface xe0
(config)#interface xe0.1	Create subinterface in xe10
(config-if)# encapsulation dot1q 20	Configure encapsulation as dotq
(config-if)# ip address 10.10.10.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4

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OSPF Configuration:

`(config)#router ospf 1`	Enter the Router OSPF mode.
`(config-router)# ospf router-id 2.2.2.2`	Router-ID configurations
`(config-router)# network 2.2.2.2/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`(config-router)# network 10.10.10.0/24 area 0.0.0.0`	Advertise network address in OSPF.

BGP Configuration:

`(config-router)#router bgp 65010`	Enter the Router BGP mode, ASN: 100
`(config-router)# neighbor 3.3.3.3 remote-as 65010`	Configuring MH-2 as iBGP neighbor using it's loopback IP
`(config-router)# neighbor 3.3.3.3 update-source lo`	Source of routing updates as loopback
`(config-router)# neighbor 5.5.5.5 remote-as 65010`	Configuring SH-1 as iBGP neighbor using it's loopback IP
`(config-router)# neighbor 5.5.5.5 update-source lo`	Source of routing updates as loopback
`(config-router)# neighbor 6.6.6.6 remote-as 65010`	Configuring SH-2 as iBGP neighbor using it's loopback IP
`(config-router)# neighbor 6.6.6.6 update-source lo`	Source of routing updates as loopback
`(config-router)# address-family l2vpn evpn`	Entering into address family mode as EVPN
`(config-router-af)# neighbor 3.3.3.3 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# neighbor 5.5.5.5 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# neighbor 6.6.6.6 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# exit-address-family`	Exiting of Address family mode
`(config-router)# address-family ipv4 vrf evpn`	Entering into VRF address family mode
`(config-router-af)# redistribute connected`	Redistribute connected routes to the network
`(config-router-af)# exit-address-family`	Exiting of Address family mode

Access Port Configuration:

`(config)#interface xe9`	Enter configuration mode
`(config-if)# mtu 9216`	Configure MTU
`(config-if)# channel-group 10000 mode active`	Configure physical interface xe9 as LAG member po10000
`(config-if)#exit`	Exit from interface xe9
`(config)#interface po10000`	Create LAG interface po10000
`(config-if)# mtu 9216`	Configure MTU
`(config-if)# description connected to Switch`	Configure Interface description
`(config-if)# evpn multi-homed system-mac 0000.1111.aaaa`	Configure system MAC for multi homing
`(config)#interface po10000.100 switchport`	Creating L2 sub interface of physical interface xe9
`(config-if)# encapsulation dot1q 100`	Setting Encapsulation to dot1q with VLAN ID 100
`(config-if)#rewrite pop`	Configure rewrite with action pop
`(config-if)#mtu 9216`	Configure MTU as 9216
`(config-if)# access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-acc-if-evpn)# map vpn-id 100`	Map VPN-ID 202
`(config-acc-if-evpn)#exit`	Exiting out of access interface mode
`(config)#interface po10000.200 switchport`	Creating L2 sub interface of physical interface xe9
`(config-if)# encapsulation dot1q 200`	Setting Encapsulation to dot1q with VLAN ID 200
`(config-if)#rewrite pop`	Configure rewrite with action pop
`(config-if)#mtu 9216`	Configure MTU as 9216
`(config-if)# access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-acc-if-evpn)# map vpn-id 200`	Map VPN-ID 202
`(config-acc-if-evpn)#exit`	Exiting out of access interface mode

MH-2:

Enable EVPN MPLS and IRB:

`#configure terminal`	Enter configuration mode.
`(config)#hardware-profile filter evpn-mpls-mh enable`	Configure hardware profile to enable EVPN MPLS multi homing in hardware
`(config)#evpn mpls enable`	Enable EVPN MPLS globally
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB globally
`(config)#evpn mpls multihoming enable`	Enable EVPN MPLS multihoming globally

Loopback Interface:

`(config-if)#interface lo`	Enter the Interface mode for the loopback interface
`(config-if)# ip address 3.3.3.3/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

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Configure MAC VRF:

`(config)#mac vrf red`	Create MAC VRF red.
`(config-vrf)# rd 3.3.3.3:100`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto route target (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode
`(config)#mac vrf blue`	Create MAC VRF blue.
`(config-vrf)# rd 3.3.3.3:200`	Configure route distinguisher
`(config-vrf)# route-target both evpn-auto-rt`	Configure route target as evpn auto route target (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode

Configure Anycast Gateway MAC:

`(config)#evpn irb-forwarding anycastgateway-mac 0011.2233.4455`	Configure anycast gateway MAC globally

Creating EVPN MPLS ID:

`(config)#evpn mpls vtep-ip-global 3.3.3.3`	Configure VTEP global IP
`(config)#evpn mpls id 100`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp red`	Map the MAC VRF red
`(config-evpn-mpls)# evpn irb irb100`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode
`(config)#evpn mpls id 200`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachabilityprotocol evpn-bgp blue`	Map the MAC VRF blue
`(config-evpn-mpls)# evpn irb irb200`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

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Global LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 3.3.3.3	Configure LDP transport address
(config-router)# targeted-peer ipv4 5.5.5.5	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)# targeted-peer ipv4 6.6.6.6	Configure LDP target peer address (SH)
(config-router-targeted-peer)#exit	Exit from LDP target peer mode
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side:

(config-if)#interface xe10	Enter the configuration mode.
(config-if)# description connected to P1	Configure Interface description
(config-if)# ip address 20.20.20.1/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# mpls ldp-igp sync ospf	Enable LDP IGP sync
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# ospf router-id 3.3.3.3	Router-ID configurations
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 20.20.20.0/24 area 0.0.0.0	Advertise network address in OSPF.

BGP Configuration:

(config-router)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 2.2.2.2 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 5.5.5.5 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 6.6.6.6 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 6.6.6.6 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 2.2.2.2 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 5.5.5.5 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 6.6.6.6 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf evpn_anycast	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration:

(config)#interface xe21	Enter configuration mode
(config-if)# mtu 9216	Configure MTU
(config-if)# channel-group 10000 mode active	Configure physical interface xe21 as LAG member po10000
(config-if)#exit	Exit from interface xe21
(config)#interface po10000	Create LAG interface po10000
(config-if)# mtu 9216	Configure MTU
(config-if)# description connected to Switch	Configure Interface description
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po10000.100 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100

(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 100	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode
(config)#interface po10000.200 switchport	Creating L2 sub interface of physical interface xe21
(config-if)# encapsulation dot1q 200	Setting Encapsulation to dot1q with VLAN ID 200
(config-if)#rewrite pop	Configure rewrite with action pop
(config-if)#mtu 9216	Configure MTU as 9216
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 200	Map VPN-ID 202
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

Note: Remote entries cannot be fetched from through MAC table/ARP cache/ND cache. However they can be fetched from the BGP table.

MH-1:

```
MH-1#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
_________________________________________________________________________________________
________________________________________
100      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2         6.6.6.6
100      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2         3.3.3.3
100      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2         5.5.5.5
100    ----       --      AC   po10000.100 00:00:00:11:11:aa:aa:00:00:00 ----     DF
----             ----
200      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2         6.6.6.6
200      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2         3.3.3.3
200      ----         L2       NW   ----      ----                          ----      -
---      2.2.2.2         5.5.5.5
```

```
200    ----      --     AC  po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----    DF
----          ----

Total number of entries are 8
MH-1#

MH-1#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=======================================================================================
2.2.2.2          6.6.6.6          Installed     01:38:59      01:38:59      200
2.2.2.2          6.6.6.6          Installed     01:38:59      01:38:59      100
2.2.2.2          3.3.3.3          Installed     01:38:59      01:38:59      200
2.2.2.2          3.3.3.3          Installed     01:38:59      01:38:59      100
2.2.2.2          5.5.5.5          Installed     01:38:59      01:38:59      200
2.2.2.2          5.5.5.5          Installed     01:38:59      01:38:59      100

Total number of entries are 6
MH-1#

MH-1#sh evpn mpls mac-table
============================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
============================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
____________________________________________________________________________________________
__________________________________________________

100        ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote   -------    0        -------
100        ----      ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
200        ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote   -------    0        -------
200        ----      ----      ----      0010.9400.0005 5.5.5.5
Dynamic Remote  -------    0        -------

Total number of entries are : 4

MH-1#

MH-1#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.2        0010.9400.0001 Dynamic Remote ----
```

```
100      80.80.1.3        0077.8899.5566 Static Remote  ----
200      90.90.1.3        0077.8899.5566 Static Remote  ----
200      90.90.1.4        0010.9400.0005 Dynamic Remote ----
Total number of entries are 4
MH-1#

MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS

RD[2.2.2.2:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS

RD[3.3.3.3:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS
MH-1#

MH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[2.2.2.2:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS

RD[3.3.3.3:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
MH-1#

MH-1#sh evpn mpls label esi
S - Self
R - Remote
ESI                            PE-IP-ADDRESS         ESI-LABEL
```

```
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)          16
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)          16
MH-1#

MH-1#sh evpn mpls label alias
S - Self
R - Remote
ESI                            PE-IP-ADDRESS       TENANT              ALIAS-LABEL
=======================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)         100                   17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(S)         200                   18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)         100                   17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)         200                   18
MH-1#

MH-1#sh bgp l2vpn evpn
BGP table version is 3, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network        Next Hop          Metric    LocPrf      Weight    Path  Peer
Encap

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                      6.6.6.6            0       100       0    ?  6.6.6.6        MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                      6.6.6.6            0       100       0    ?  6.6.6.6        MPLS

RD[2.2.2.2:100] VRF[red]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0       100       32768  i  ----------     MPLS
* i                   3.3.3.3            0       100       0    i  3.3.3.3        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                      3.3.3.3            0       100       0    i  3.3.3.3        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                      3.3.3.3            0       100       0    i  3.3.3.3        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                      3.3.3.3            0       100       0    i  3.3.3.3        MPLS
* i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
```

```
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS
*>   [3]:[100]:[32,2.2.2.2]
                   2.2.2.2           0       100      32768  i  ----------     MPLS
* i  [3]:[100]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [3]:[100]:[32,5.5.5.5]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [3]:[100]:[32,6.6.6.6]
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS

RD[2.2.2.2:200] VRF[blue]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                   2.2.2.2           0       100      32768  i  ----------     MPLS
* i                 3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS
*>   [3]:[200]:[32,2.2.2.2]
                   2.2.2.2           0       100      32768  i  ----------     MPLS
* i  [3]:[200]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [3]:[200]:[32,5.5.5.5]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [3]:[200]:[32,6.6.6.6]
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS

RD[2.2.2.2:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                   2.2.2.2           0       100      32768  i  ----------     MPLS
*>   [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                   2.2.2.2           0       100      32768  i  ----------     MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                    3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[3.3.3.3:200]
```

```
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [3]:[200]:[32,3.3.3.3]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[5.5.5.5:100]
*>i  [3]:[100]:[32,5.5.5.5]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                     5.5.5.5            0        100       0    i  5.5.5.5        MPLS

RD[6.6.6.6:100]
*>i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
                     6.6.6.6            0        100       0    i  6.6.6.6        MPLS
*>i  [3]:[100]:[32,6.6.6.6]
                     6.6.6.6            0        100       0    i  6.6.6.6        MPLS

RD[6.6.6.6:200]
*>i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                     6.6.6.6            0        100       0    i  6.6.6.6        MPLS
*>i  [3]:[200]:[32,6.6.6.6]
                     6.6.6.6            0        100       0    i  6.6.6.6        MPLS

Total number of prefixes 39
MH-1#

MH-1#sh bgp l2vpn evpn prefix-route

RD[30:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0              0       24               80.80.1.0       0.0.0.0         16
6.6.6.6         MPLS      e8c5:7aff:96de
0              0       24               90.90.1.0       0.0.0.0         16
6.6.6.6         MPLS      e8c5:7aff:96de
MH-1#

MH-1#sh bgp l2vpn evpn summary
BGP router identifier 2.2.2.2, local AS number 65010
```

```
BGP table version is 3
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
3.3.3.3                4 65010  244       241      2      0      0  01:39:10
8      3      2      2      1      0
5.5.5.5                4 65010  237       238      2      0      0  01:39:10
4      0      2      2      0      0
6.6.6.6                4 65010  239       240      2      0      0  01:39:10
6      0      2      2      0      2

Total number of neighbors 3

Total number of Established sessions 3
MH-1#

MH-1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   3.3.3.3/32         1         2
                                    1         -          Yes   LSP_DEFAULT  25605
xe0.1       No    10.10.10.2
   L>   4.4.4.4/32         2         5
                                    4         -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
   L>   5.5.5.5/32         3         7
                                    6         -          Yes   LSP_DEFAULT  25606
xe0.1       No    10.10.10.2
   L>   6.6.6.6/32         4         10
                                    9         -          Yes   LSP_DEFAULT  25609
xe0.1       No    10.10.10.2
   L>   20.20.20.0/24      5         5
                                    4         -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
   L>   30.30.30.0/24      6         5
                                    4         -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
   L>   40.40.40.0/24      7         5
                                    4         -          Yes   LSP_DEFAULT  3
xe0.1       No    10.10.10.2
MH-1#

MH-1#sh ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
5.5.5.5                   xe0.1      Passive   OPERATIONAL   30    01:39:03
```

```
6.6.6.6                  xe0.1      Passive   OPERATIONAL   30    01:39:03
4.4.4.4                  xe0.1      Passive   OPERATIONAL   30    01:39:01
MH-1#

MH-1#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:35   10.10.10.2     xe0.1                0
MH-1#
```

MH-2:

```
MH-2#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
_____________________________________________________________________________________
________________________________________
100      ----         L2        NW   ----      ----                        ----      -
---      3.3.3.3        5.5.5.5
100      ----         L2        NW   ----      ----                        ----      -
---      3.3.3.3        2.2.2.2
100      ----         L2        NW   ----      ----                        ----      -
---      3.3.3.3        6.6.6.6
100      ----         --        AC   po10000.100 00:00:00:11:11:aa:aa:00:00:00 ----
NON-DF    ----           ----
200      ----         L2        NW   ----      ----                        ----      -
---      3.3.3.3        5.5.5.5
200      ----         L2        NW   ----      ----                        ----      -
---      3.3.3.3        2.2.2.2
200      ----         L2        NW   ----      ----                        ----      -
---      3.3.3.3        6.6.6.6
200      ----         --        AC   po10000.200 00:00:00:11:11:aa:aa:00:00:00 ----
NON-DF    ----           ----

Total number of entries are 8
MH-2#

MH-2#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
3.3.3.3          5.5.5.5          Installed     01:52:28      01:52:28      200
```

```
3.3.3.3         5.5.5.5         Installed     01:52:28      01:52:28      100
3.3.3.3         2.2.2.2         Installed     01:41:32      01:41:32      200
3.3.3.3         2.2.2.2         Installed     01:41:32      01:41:32      100
3.3.3.3         6.6.6.6         Installed     01:52:28      01:52:28      200
3.3.3.3         6.6.6.6         Installed     01:52:28      01:52:28      100

Total number of entries are 6
MH-2#

MH-2#sh evpn mpls mac-table
==============================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
==============================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
______________________________________________________________________________________________
__________________________________________________

100         ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote   -------    0        -------
100        po10000.100 ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Local   -------    0        -------
200         ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote   -------    0        -------
200         ----      ----      ----      0010.9400.0005 5.5.5.5
Dynamic Remote  -------    0        -------

Total number of entries are : 4

MH-2#

MH-2#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.2        0010.9400.0001 Dynamic Local  249      2
100      80.80.1.3        0077.8899.5566 Static Remote  ----
200      90.90.1.3        0077.8899.5566 Static Remote  ----
200      90.90.1.4        0010.9400.0005 Dynamic Remote ----
Total number of entries are 4
MH-2#

MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS
```

```
RD[3.3.3.3:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS

RD[3.3.3.3:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS
MH-2#

MH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[2.2.2.2:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
MH-2#

MH-2#sh evpn mpls label esi
S - Self
R - Remote
ESI                            PE-IP-ADDRESS        ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)             16
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)             16
MH-2#

MH-2#sh evpn mpls label alias
S - Self
R - Remote
ESI                            PE-IP-ADDRESS        TENANT                ALIAS-LABEL
================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            100                   17
```

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```
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)          200                  18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)          100                  17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(S)          200                  18
MH-2#

MH-2#sh bgp l2vpn evpn
BGP table version is 7, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network        Next Hop          Metric    LocPrf      Weight     Path  Peer
Encap

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                      6.6.6.6            0        100       0    ?  6.6.6.6        MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                      6.6.6.6            0        100       0    ?  6.6.6.6        MPLS

RD[2.2.2.2:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[3.3.3.3:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                      2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>                   3.3.3.3            0        100     32768  i  ----------     MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
```

```
                    2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                   3.3.3.3            0        100      32768  i  ----------     MPLS
*>   [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                   3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS
* i  [3]:[100]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>   [3]:[100]:[32,3.3.3.3]
                   3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [3]:[100]:[32,5.5.5.5]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [3]:[100]:[32,6.6.6.6]
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS

RD[3.3.3.3:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                    2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>                 3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS
* i  [3]:[200]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>   [3]:[200]:[32,3.3.3.3]
                   3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [3]:[200]:[32,5.5.5.5]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS
* i  [3]:[200]:[32,6.6.6.6]
                    6.6.6.6            0        100       0    i  6.6.6.6        MPLS

RD[3.3.3.3:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                   3.3.3.3            0        100      32768  i  ----------     MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                    2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>   [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                   3.3.3.3            0        100      32768  i  ----------     MPLS

RD[5.5.5.5:100]
*>i  [3]:[100]:[32,5.5.5.5]
                    5.5.5.5            0        100       0    i  5.5.5.5        MPLS

RD[5.5.5.5:200]
```

```
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                    5.5.5.5            0       100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                    5.5.5.5            0       100       0    i  5.5.5.5         MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                    5.5.5.5            0       100       0    i  5.5.5.5         MPLS

RD[6.6.6.6:100]
*>i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
                    6.6.6.6            0       100       0    i  6.6.6.6         MPLS
*>i  [3]:[100]:[32,6.6.6.6]
                    6.6.6.6            0       100       0    i  6.6.6.6         MPLS

RD[6.6.6.6:200]
*>i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                    6.6.6.6            0       100       0    i  6.6.6.6         MPLS
*>i  [3]:[200]:[32,6.6.6.6]
                    6.6.6.6            0       100       0    i  6.6.6.6         MPLS

Total number of prefixes 37
MH-2#

MH-2#sh bgp l2vpn evpn prefix-route

RD[30:200]
ESI            Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop         Encap     Router-Mac
0              0       24               80.80.1.0       0.0.0.0         16
6.6.6.6         MPLS      e8c5:7aff:96de
0              0       24               90.90.1.0       0.0.0.0         16
6.6.6.6         MPLS      e8c5:7aff:96de
MH-2#

MH-2#sh bgp l2vpn evpn summary
BGP router identifier 3.3.3.3, local AS number 65010
BGP table version is 7
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
2.2.2.2                4 65010  279       273      7      0      0  01:41:33
6      3      0      2      1      0
5.5.5.5                4 65010  270       276      7      0      0  01:52:30
4      0      2      2      0      0
6.6.6.6                4 65010  271       277      7      0      0  01:52:30
6      0      2      2      0      2

Total number of neighbors 3

Total number of Established sessions 3
MH-2#
```

```
MH-2#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          5         13
                                    12        -           Yes   LSP_DEFAULT  25600
xe10        No    20.20.20.2
   L>   4.4.4.4/32          2         4
                                    3         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
   L>   5.5.5.5/32          3         6
                                    5         -           Yes   LSP_DEFAULT  25610
xe10        No    20.20.20.2
   L>   6.6.6.6/32          4         8
                                    7         -           Yes   LSP_DEFAULT  25611
xe10        No    20.20.20.2
   L>   10.10.10.0/24       1         4
                                    3         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
   L>   30.30.30.0/24       6         4
                                    3         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
   L>   40.40.40.0/24       7         4
                                    3         -           Yes   LSP_DEFAULT  3
xe10        No    20.20.20.2
MH-2#

MH-2#sh ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
4.4.4.4                   xe10       Passive   OPERATIONAL   30    01:52:33
5.5.5.5                   xe10       Passive   OPERATIONAL   30    01:52:10
6.6.6.6                   xe10       Passive   OPERATIONAL   30    01:52:10
MH-2#

MH-2#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:31   20.20.20.2     xe10                  0
MH-2#
```

SH-1:

```
SH-1#sh evpn mpls
```

```
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr         Dst-Addr
________________________________________________________________________________________
________________________________________
100      ----         L2       NW   ----      ----                          ----      -
---      5.5.5.5          6.6.6.6
100      ----         L2       NW   ----      ----                          ----      -
---      5.5.5.5          2.2.2.2
100      ----         L2       NW   ----      ----                          ----      -
---      5.5.5.5          3.3.3.3
100      ----         --       AC   sa9000.100 --- Single Homed Port ---    ----      -
---      ----             ----
200      ----         L2       NW   ----      ----                          ----      -
---      5.5.5.5          6.6.6.6
200      ----         L2       NW   ----      ----                          ----      -
---      5.5.5.5          2.2.2.2
200      ----         L2       NW   ----      ----                          ----      -
---      5.5.5.5          3.3.3.3
200      ----         --       AC   sa9000.200 --- Single Homed Port ---    ----      -
---      ----             ----

Total number of entries are 8
SH-1#
SH-1#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
====================================================================================
5.5.5.5          6.6.6.6          Installed     01:57:20      01:57:20      200
5.5.5.5          6.6.6.6          Installed     01:57:20      01:57:20      100
5.5.5.5          2.2.2.2          Installed     01:44:57      01:44:57      200
5.5.5.5          2.2.2.2          Installed     01:44:57      01:44:57      100
5.5.5.5          3.3.3.3          Installed     01:55:53      01:55:53      200
5.5.5.5          3.3.3.3          Installed     01:55:53      01:55:53      100

Total number of entries are 6
SH-1#
SH-1#sh evpn mpls mac-table
========================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
________________________________________________________________________________________
__________________________________________________
```

```
100        ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote   -------    0        -------
100        ----      ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
200        ----      ----      ----      0077.8899.5566 6.6.6.6
Static Remote   -------    0        -------
200        sa9000.200 ----      ----      0010.9400.0005 5.5.5.5
Dynamic Local   -------    0        -------

Total number of entries are : 4

SH-1#

SH-1#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.2        0010.9400.0001 Dynamic Remote ----
100      80.80.1.3        0077.8899.5566 Static Remote  ----
200      90.90.1.3        0077.8899.5566 Static Remote  ----
200      90.90.1.4        0010.9400.0005 Dynamic Local  443      2
Total number of entries are 4
SH-1#

SH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS

RD[3.3.3.3:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS

RD[5.5.5.5:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS
SH-1#

SH-1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]
```

```
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[2.2.2.2:200]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200]
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS

RD[5.5.5.5:100] VRF[red]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[5.5.5.5:200] VRF[blue]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
SH-1#

SH-1#sh evpn mpls label esi
S - Self
R - Remote
ESI                             PE-IP-ADDRESS        ESI-LABEL
================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)              16
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)              16
SH-1#

SH-1#sh evpn mpls label alias
S - Self
R - Remote
ESI                             PE-IP-ADDRESS        TENANT                ALIAS-LABEL
=======================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            100                     17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            200                     18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            100                     17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            200                     18
SH-1#

SH-1#sh bgp l2vpn evpn
BGP table version is 10, local router ID is 5.5.5.5
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
```

```
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network         Next Hop           Metric    LocPrf      Weight     Path  Peer
Encap

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     6.6.6.6            0        100       0    ?  6.6.6.6        MPLS
*>i  [5]:[0]:[0]:[24]:[90.90.1.0]:[0.0.0.0]:[16]
                     6.6.6.6            0        100       0    ?  6.6.6.6        MPLS

RD[2.2.2.2:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [3]:[200]:[32,3.3.3.3]
```

```
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS

RD[5.5.5.5:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i                  3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i                  3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
                     6.6.6.6            0        100       0    i  6.6.6.6        MPLS
* i  [3]:[100]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [3]:[100]:[32,3.3.3.3]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>   [3]:[100]:[32,5.5.5.5]
                    5.5.5.5            0        100      32768  i  ----------     MPLS
* i  [3]:[100]:[32,6.6.6.6]
                     6.6.6.6            0        100       0    i  6.6.6.6        MPLS

RD[5.5.5.5:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i                  3.3.3.3            0        100       0    i  3.3.3.3        MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i                  3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>   [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                    5.5.5.5            0        100      32768  i  ----------     MPLS
*>   [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                    5.5.5.5            0        100      32768  i  ----------     MPLS
* i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                     6.6.6.6            0        100       0    i  6.6.6.6        MPLS
* i  [3]:[200]:[32,2.2.2.2]
                     2.2.2.2            0        100       0    i  2.2.2.2        MPLS
* i  [3]:[200]:[32,3.3.3.3]
                     3.3.3.3            0        100       0    i  3.3.3.3        MPLS
*>   [3]:[200]:[32,5.5.5.5]
                    5.5.5.5            0        100      32768  i  ----------     MPLS
* i  [3]:[200]:[32,6.6.6.6]
```

```
                      6.6.6.6             0        100       0    i  6.6.6.6        MPLS

RD[6.6.6.6:100]
*>i  [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
                      6.6.6.6             0        100       0    i  6.6.6.6        MPLS
*>i  [3]:[100]:[32,6.6.6.6]
                      6.6.6.6             0        100       0    i  6.6.6.6        MPLS

RD[6.6.6.6:200]
*>i  [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                      6.6.6.6             0        100       0    i  6.6.6.6        MPLS
*>i  [3]:[200]:[32,6.6.6.6]
                      6.6.6.6             0        100       0    i  6.6.6.6        MPLS

Total number of prefixes 38
SH-1#

SH-1#sh bgp l2vpn evpn prefix-route

RD[30:200]
ESI             Eth-Tag Prefix-Length    IP-Address      GW-IPAddress    L3VNID/LABEL
Nexthop          Encap     Router-Mac
0               0       24               80.80.1.0       0.0.0.0         16
6.6.6.6          MPLS      e8c5:7aff:96de
0               0       24               90.90.1.0       0.0.0.0         16
6.6.6.6          MPLS      e8c5:7aff:96de
SH-1#

SH-1#sh bgp l2vpn evpn summary
BGP router identifier 5.5.5.5, local AS number 65010
BGP table version is 10
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
2.2.2.2                4 65010  407       379      9     0      0  01:44:58
6      3      0      2      1      0
3.3.3.3                4 65010  416       390      8     0      0  01:55:55
8      3      2      2      1      0
6.6.6.6                4 65010  399       396      7     0      0  02:04:33
6      0      2      2      0      2

Total number of neighbors 3

Total number of Established sessions 3
SH-1#

SH-1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
```

```
      U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
      (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          4         2
                                    1         -          Yes   LSP_DEFAULT  25601
xe6         No    30.30.30.2
   L>   3.3.3.3/32          7         40
                                    39        -          Yes   LSP_DEFAULT  25607
xe6         No    30.30.30.2
   L>   4.4.4.4/32          2         35
                                    7         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   6.6.6.6/32          3         37
                                    36        -          Yes   LSP_DEFAULT  25603
xe6         No    30.30.30.2
   L>   10.10.10.0/24       1         35
                                    7         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   20.20.20.0/24       6         35
                                    7         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   40.40.40.0/24       5         35
                                    7         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
SH-1#
SH-1#sh ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
2.2.2.2                   xe6        Active     OPERATIONAL   30    01:44:53
3.3.3.3                   xe6        Active     OPERATIONAL   30    01:55:35
6.6.6.6                   xe6        Passive    OPERATIONAL   30    01:57:21
4.4.4.4                   xe6        Active     OPERATIONAL   30    01:57:21
SH-1#
SH-1#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/Backup      00:00:31    30.30.30.2      xe6                   0
SH-1#
```

SH-2:

```
SH-2#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged
```

```
VPN-ID   EVI-Name     EVI-Type Type Interface ESI                          VLAN      DF-
Status Src-Addr          Dst-Addr
________________________________________________________________________________________
________________________________________
100      ----         L2       NW   ----      ----                         ----      -
---      6.6.6.6          3.3.3.3
100      ----         L2       NW   ----      ----                         ----      -
---      6.6.6.6          2.2.2.2
100      ----         L2       NW   ----      ----                         ----      -
---      6.6.6.6          5.5.5.5
200      ----         L2       NW   ----      ----                         ----      -
---      6.6.6.6          3.3.3.3
200      ----         L2       NW   ----      ----                         ----      -
---      6.6.6.6          2.2.2.2
200      ----         L2       NW   ----      ----                         ----      -
---      6.6.6.6          5.5.5.5

Total number of entries are 6
SH-2#
SH-2#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=====================================================================================
6.6.6.6          3.3.3.3          Installed     01:57:22      01:57:22      200
6.6.6.6          3.3.3.3          Installed     01:57:22      01:57:22      100
6.6.6.6          2.2.2.2          Installed     01:46:26      01:46:26      200
6.6.6.6          2.2.2.2          Installed     01:46:26      01:46:26      100
6.6.6.6          5.5.5.5          Installed     01:58:49      01:58:49      200
6.6.6.6          5.5.5.5          Installed     01:58:49      01:58:49      100

Total number of entries are 6
SH-2#
SH-2#sh evpn mpls mac-table
=========================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
=========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
_________________________________________________________________________________________
__________________________________________________

100        irb100    ----      ----      0077.8899.5566 6.6.6.6
Static Local    -------    0        -------
100        ----      ----      ----      0010.9400.0001 00:00:00:11:11:aa:aa:00:00:00
Dynamic Remote  -------    0        -------
200        irb200    ----      ----      0077.8899.5566 6.6.6.6
Static Local    -------    0        -------
200        ----      ----      ----      0010.9400.0005 5.5.5.5
Dynamic Remote  -------    0        -------

Total number of entries are : 4
```

```
SH-2#
SH-2#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  300 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
100      80.80.1.2        0010.9400.0001 Dynamic Remote ----
100      80.80.1.3        0077.8899.5566 Static Local   ----
200      90.90.1.3        0077.8899.5566 Static Local   ----
200      90.90.1.4        0010.9400.0005 Dynamic Remote ----
Total number of entries are 4
SH-2#
SH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[2.2.2.2:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS

RD[3.3.3.3:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS

RD[6.6.6.6:100] VRF[red]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS

RD[6.6.6.6:200] VRF[blue]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  4294967295  16             3.3.3.3         MPLS
SH-2#
SH-2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[2.2.2.2:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS

RD[2.2.2.2:200]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS

RD[3.3.3.3:100]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[3.3.3.3:200]
```

```
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS

RD[6.6.6.6:100] VRF[red]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  100         17             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  100         17             3.3.3.3         MPLS

RD[6.6.6.6:200] VRF[blue]:
ESI                             Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  200         18             2.2.2.2         MPLS
00:00:00:11:11:aa:aa:00:00:00  200         18             3.3.3.3         MPLS
SH-2#
SH-2#sh evpn mpls label esi
S - Self
R - Remote
ESI                             PE-IP-ADDRESS        ESI-LABEL
=================================================================
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)             16
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)             16
SH-2#
SH-2#sh evpn mpls label alias
S - Self
R - Remote
ESI                             PE-IP-ADDRESS        TENANT               ALIAS-LABEL
=======================================================================================
======
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            100                   17
00:00:00:11:11:aa:aa:00:00:00  2.2.2.2(R)            200                   18
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            100                   17
00:00:00:11:11:aa:aa:00:00:00  3.3.3.3(R)            200                   18
SH-2#
SH-2#sh bgp l2vpn evpn
BGP table version is 9, local router ID is 6.6.6.6
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network         Next Hop           Metric    LocPrf      Weight     Path  Peer
Encap

RD[2.2.2.2:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
```

```
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>i  [3]:[100]:[32,2.2.2.2]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS

RD[2.2.2.2:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>i  [3]:[200]:[32,2.2.2.2]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS

RD[2.2.2.2:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,2.2.2.2]
                     2.2.2.2             0        100       0    i  2.2.2.2         MPLS

RD[3.3.3.3:100]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[100]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:200]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [3]:[200]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[3.3.3.3:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,3.3.3.3]
                     3.3.3.3             0        100       0    i  3.3.3.3         MPLS

RD[5.5.5.5:100]
*>i  [3]:[100]:[32,5.5.5.5]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS

RD[5.5.5.5:200]
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
*>i  [3]:[200]:[32,5.5.5.5]
                     5.5.5.5             0        100       0    i  5.5.5.5         MPLS
```

```
RD[6.6.6.6:100] VRF[red]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[17]
                    2.2.2.2           0       100       0    i  2.2.2.2         MPLS
* i                 3.3.3.3           0       100       0    i  3.3.3.3         MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    2.2.2.2           0       100       0    i  2.2.2.2         MPLS
* i                 3.3.3.3           0       100       0    i  3.3.3.3         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[0]:[17]
                    3.3.3.3           0       100       0    i  3.3.3.3         MPLS
* i  [2]:[00:00:00:11:11:aa:aa:00:00:00]:[100]:[48,0010:9400:0001]:[32,80.80.1.2]:[17]
                    3.3.3.3           0       100       0    i  3.3.3.3         MPLS
*>   [2]:[0]:[100]:[48,0077:8899:5566]:[32,80.80.1.3]:[17]
                   6.6.6.6           0       100      32768  i  ----------      MPLS
* i  [3]:[100]:[32,2.2.2.2]
                    2.2.2.2           0       100       0    i  2.2.2.2         MPLS
* i  [3]:[100]:[32,3.3.3.3]
                    3.3.3.3           0       100       0    i  3.3.3.3         MPLS
* i  [3]:[100]:[32,5.5.5.5]
                    5.5.5.5           0       100       0    i  5.5.5.5         MPLS
*>   [3]:[100]:[32,6.6.6.6]
                   6.6.6.6           0       100      32768  i  ----------      MPLS

RD[6.6.6.6:200] VRF[blue]:
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[200]:[18]
                    2.2.2.2           0       100       0    i  2.2.2.2         MPLS
* i                 3.3.3.3           0       100       0    i  3.3.3.3         MPLS
* i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                    2.2.2.2           0       100       0    i  2.2.2.2         MPLS
* i                 3.3.3.3           0       100       0    i  3.3.3.3         MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[0]:[641]
                    5.5.5.5           0       100       0    i  5.5.5.5         MPLS
* i  [2]:[0]:[200]:[48,0010:9400:0005]:[32,90.90.1.4]:[641]
                    5.5.5.5           0       100       0    i  5.5.5.5         MPLS
*>   [2]:[0]:[200]:[48,0077:8899:5566]:[32,90.90.1.3]:[18]
                   6.6.6.6           0       100      32768  i  ----------      MPLS
* i  [3]:[200]:[32,2.2.2.2]
                    2.2.2.2           0       100       0    i  2.2.2.2         MPLS
* i  [3]:[200]:[32,3.3.3.3]
                    3.3.3.3           0       100       0    i  3.3.3.3         MPLS
* i  [3]:[200]:[32,5.5.5.5]
                    5.5.5.5           0       100       0    i  5.5.5.5         MPLS
*>   [3]:[200]:[32,6.6.6.6]
                   6.6.6.6           0       100      32768  i  ----------      MPLS

Total number of prefixes 36
SH-2#
SH-2#sh bgp l2vpn evpn prefix-route
SH-2#
SH-2#sh bgp l2vpn evpn summary
BGP router identifier 6.6.6.6, local AS number 65010
```

```
BGP table version is 9
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
2.2.2.2                4 65010  410       398      8      0      0  01:46:28
6      3      0      2      1      0
3.3.3.3                4 65010  422       402      7      0      0  01:57:25
8      3      2      2      1      0
5.5.5.5                4 65010  391       406      5      0      0  02:06:03
4      0      2      2      0      0

Total number of neighbors 3

Total number of Established sessions 3
SH-2#
SH-2#sh ip bgp vrf evpn_anycast
BGP table version is 1, local router ID is 90.90.1.3
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path
*>   80.80.1.0/24     0.0.0.0              0        100       32768  ?
*>   90.90.1.0/24     0.0.0.0              0        100       32768  ?

Total number of prefixes 2
SH-2#
SH-2#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          4         3
                                    2         -          Yes   LSP_DEFAULT  25604
xe14        No    40.40.40.2
   L>   3.3.3.3/32          7         41
                                    40        -          Yes   LSP_DEFAULT  25608
xe14        No    40.40.40.2
   L>   4.4.4.4/32          3         39
                                    11        -          Yes   LSP_DEFAULT  3
xe14        No    40.40.40.2
   L>   5.5.5.5/32          1         34
                                    33        -          Yes   LSP_DEFAULT  25602
xe14        No    40.40.40.2
   L>   10.10.10.0/24       2         39
```

```
                                    11        -          Yes   LSP_DEFAULT  3
xe14        No    40.40.40.2
   L>   20.20.20.0/24       6         39
                                    11        -          Yes   LSP_DEFAULT  3
xe14        No    40.40.40.2
   L>   30.30.30.0/24       5         39
                                    11        -          Yes   LSP_DEFAULT  3
xe14        No    40.40.40.2
SH-2#
SH-2#sh ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2                   xe14       Active    OPERATIONAL   30    01:46:21
3.3.3.3                   xe14       Active    OPERATIONAL   30    01:57:03
5.5.5.5                   xe14       Active    OPERATIONAL   30    01:58:50
4.4.4.4                   xe14       Active    OPERATIONAL   30    01:58:50
SH-2#
SH-2#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
4.4.4.4          1   Full/Backup      00:00:30    40.40.40.2      xe14                  0
SH-2#
SH-2#sh nvo vxlan l3vni-map
 L3VNI        L2VNI        IRB-interface
===================================
 10000        100          irb100
 10000        200          irb200

SH-2#
```

P1:

```
P1#sh ip ospf neighbor

Total number of full neighbors: 4
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/Backup      00:00:35    10.10.10.1      xe4.1
0
3.3.3.3          1   Full/Backup      00:00:37    20.20.20.1      xe1                   0
5.5.5.5          1   Full/DR          00:00:38    30.30.30.1      xe6                   0
6.6.6.6          1   Full/DR          00:00:36    40.40.40.1      xe10                  0
P1#
P1#sh ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
3.3.3.3                   xe1        Active    OPERATIONAL   30    01:58:40
2.2.2.2                   xe4.1      Active    OPERATIONAL   30    01:47:32
```

```
5.5.5.5                   xe6        Passive   OPERATIONAL   30    02:00:03
6.6.6.6                   xe10       Passive   OPERATIONAL   30    02:00:03
P1#
P1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          2         2
                                     1         -           Yes   LSP_DEFAULT  3
xe4.1       No    10.10.10.1
   L>   3.3.3.3/32          4         47
                                     46        -           Yes   LSP_DEFAULT  3
xe1         No    20.20.20.1
   L>   5.5.5.5/32          1         38
                                     37        -           Yes   LSP_DEFAULT  3
xe6         No    30.30.30.1
   L>   6.6.6.6/32          3         44
                                     43        -           Yes   LSP_DEFAULT  3
xe10        No    40.40.40.1
P1#
```

EVPN MPLS IRB Symmetric with Host Routes

Overview

EVPN-IRB facilitates communication between two L2VNI’s with the help of Routing using IP-VRF. This features provides the Host (/32 or /128) based Symmetric IRB support which forwards the inter-subnet traffic directly towards the host (CEs) attached to VTEP (PEs).

Host based Symmetric IRB support is two modes: interface-full and interface-less.

- Interface-full mode refers to configuring of IRB interface
- Interface-less mode refers to configuring the access interface as L3 interface and using the IRB configuration. IRB interface is not used in this case.
- Interface-full mode supports “evpn irb-advertise-host-route” CLI under evpn mpls id <id>.
- Interface-less mode supports both “evpn irb-advertise-host-route” CLI under evpn mpls id <id> and “redistribute-connected-host-routes” under bgp vrf address family.
- Host based Symmetric IRB support is achieved through one of the modes:
    - “evpn irb-advertise-host-route” in interface-full mode (with IRB interface“)
    - evpn irb-advertise-host-route” in interface-less mode (without IRB interface)
    - “redistribute-connected-host-routes” in interface-less mode (without IRB interface)

Topology

Figure 2-6 depicts the EVPN MPLS IRB with LDP as underlay MPLS path.

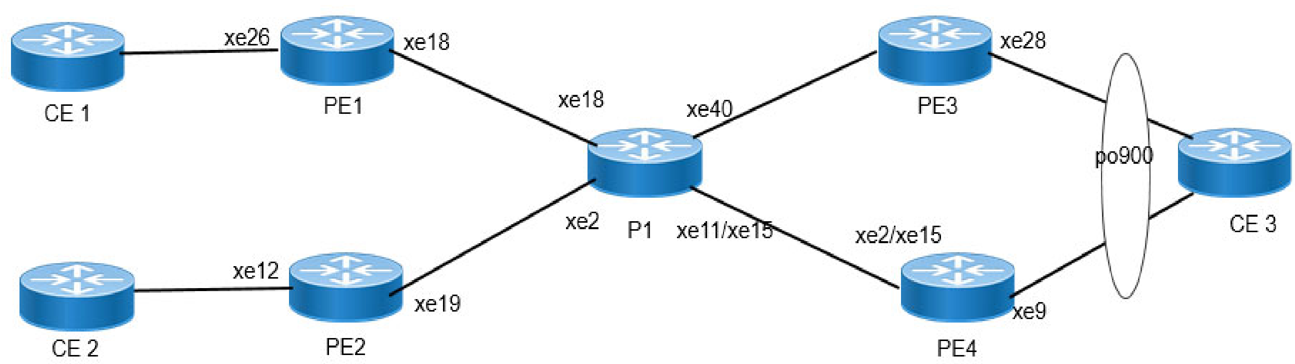

Figure 2-6: Host based symmetric IRB support

PE1

Enable EVPN MPLS and IRB

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS globally.
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB globally.

Loopback Interface

`(config-if)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)# ip address 20.20.20.20/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode.

Configure MAC VRF:

`(config)#mac vrf green`	Create MAC VRF mvrf4.
`(config-vrf)# rd 20.20.20.20:400`	Configure route distinguisher.
`(config-vrf)# route-target both 65010:400`	Configure route target as evpn auto route target (it can be configured as manual RT).
`(config-vrf)#exit`	Exit VRF mode.

Configure IP VRF:

(config)#ip vrf vrf400	Configure IP VRF vrf100.
(config-vrf)# rd 30:400	Configure route distinguisher
(config-vrf)# route-target both 100:400	Configure route target
(config-vrf)# l3vni 40000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure anycast gateway MAC:

(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.5577	Configure anycast gateway MAC globally.

Configuring IRB interface:

(config)#interface irb400	Create IRB interface irb100.
(config-irb-if)# ip vrf forwarding vrf400	Map L3 VRF to the IRB interface.
(config-irb-if)# ip address 40.40.1.1/24 anycast	Assign IP address.
(config-irb-if)# ipv6 address 5001::1/48	Assign IPv6 address.
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC.
(config-irb-if)#exit	Exit interface mode.

Creating EVPN MPLS ID:

(config)#evpn mpls vtep-ip-global 20.20.20.20	Configure VTEP global IP.
(config)#evpn mpls id 400	Create EVPN MPLS ID.
(config-evpn-mpls)# host-reachability-protocol evpn-bgp green	Map the MAC VRF mvrf4.
(config-evpn-mpls)# evpn irb irb400	Map the IRB interface.
(config-evpn-mpls)# evpn irb-advertise-host-route	Set host to route advertise.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode.

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 20.20.20.20	Set router ID of LDP.
(config-router)# targeted-peer ipv4 17.17.17.17	Configure targeted peer.
(config-router-targeted-peer)# exit	Exit from targeted-peer mode.

(config-router)# transport-address ipv4 20.20.20.20	Configure LDP transport address.
(config-router)#exit	Exit from LDP mode.

Interface Configuration Network Side

(config)#interface xe18	Configure physical interface.
(config-if)# mtu 9216	Configure MTU on the interface.
(config-if)# load-interval 30	Set load interval.
(config-if)# ip address 55.55.55.1/24	Assign IP address.
(config-if)# label-switching	Enable label switching.
(config-if)# isis network point-to-point	Configure isis as point-to-point network.
(config-if)# enable-ldp ipv4	Enable LDP IPv4.
(config-if)# ip router isis ISIS-IGP	Enable a routing process.
(config-if)#exit	Exit interface mode.
(config-if)# router isis ISIS-IGP	Enter the Router ISIS mode.
(config-router)# is-type level-1	IS Level for this routing process.
(config-router)# mpls traffic-eng router-id 20.20.20.20	Routing protocol commands for MPLS Traffic Engineering.
(config-router)# net 49.0001.0000.0000.0001.00	Configure net.
(config-router)#exit	Exit OSPF mode.

BGP Configuration

(config)#router bgp	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 11.11.11.11 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 11.11.11.11 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 22.22.22.22 remote-as 65010	Configuring PE2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 22.22.22.22 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 17.17.17.17 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 22.22.22.22 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 11.11.11.11 activate	Enabling EVPN Address family for neighbor

`(config-router-af)# neighbor 22.22.22.22 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# neighbor 17.17.17.17 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)# exit-address-family`	Exiting of Address family mode
`(config-router)# address-family ipv4 vrf vrf400`	Entering into VRF address family mode
`(config-router-af)# redistribute connected`	Redistribute connected routes to the network
`(config-router-af)# exit-address-family`	Exiting of Address family mode

Access Port Configuration:

`(config)# interface xe26`	Configure physical interface
`(config-if)# static-channel-group 10000`	Create static channel group
`(config-if)# exit`	Exit interface mode
`(config)# interface sa10000`	Configure Static channel sa10000
`(config-if)# switchport`	Make it L2 interface
`(config-if)# load-interval 30`	Set load interval
`(config-if)# mtu 9216`	Configure MTU on the interface.
`(config)# exit`	Exit interface mode
`(config)# interface sa10000.400 switchport`	Configure static sub-interface
`(config-if)# encapsulation dot1q 701`	Configure encapsulation
`(config-ig)# rewrite pop`	Pop the outer VID
`(config-if)# access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`(config-acc-if-evpn)#  map vpn-id 400`	Map VPN-ID 400
`(config-acc-if-evpn)# mac 0000.0000.aaaa ip 40.40.1.10`	Configure static mac with IP
`(config-acc-if-evpn)# mac 0000.0000.bbbb ipv6 5001:aaaa::1`	Configure static mac with IPv6
`(config-acc-if-evpn)#exit`	Exiting out of access interface mode

PE2

Enable EVPN MPLS and IRB:

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS globally
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config)#mac vrf green	Create MAC VRF mvrf4.
(config-vrf)# rd 22.22.22.22:400	Configure route distinguisher
(config-vrf)# route-target both 65010:400	Configure route target as evpn auto route target (we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf vrf400	Configure IP VRF vrf100.
(config-vrf)# rd 40:400	Configure route distinguisher
(config-vrf)# route-target both 100:400	Configure route target
(config-vrf)# l3vni 40000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure anycast gateway MAC

(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.5577	Configure anycast gateway MAC globally

Configuring IRB interface

(config)#interface irb400	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding vrf400	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 40.40.1.1/24 anycast	Assign IP address
(config-irb-if)# ipv6 address 5001::1/48	Assign IPv6 address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID:

`(config)#evpn mpls vtep-ip-global 22.22.22.22`	Configure VTEP global IP
`(config)#evpn mpls id 400`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachability-protocol evpn-bgp green`	Map the MAC VRF mvrf4
`(config-evpn-mpls)# evpn irb irb400`	Map the IRB interface
`(config-evpn-mpls)# evpn irb-advertise-host-route`	Set host to route advertise
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)# router-id 22.22.22.22`	Set router ID of LDP
`(config-router)# targeted-peer ipv4 17.17.17.17`	Configure targeted peer
`(config-router)# targeted-peer ipv4 11.11.11.11`	Configure targeted peer
`(config-router-targeted-peer)# exit`	Exit from targeted-peer mode
`(config-router)# transport-address ipv4 22.22.22.22`	Configure LDP transport address
`(config-router)#exit`	Exit from LDP mode

Interface Configuration Network Side

`(config)#interface xe19`	Configure physical interface
`(config-if)# mtu 9216`	Configure MTU on the interface.
`(config-if)# load-interval 30`	Set load interval
`(config-if)# ip address 30.30.30.1/24`	Assign IP address
`(config-if)# label-switching`	Enable label switching
`(config-if)# isis network point-to-point`	Configure isis as point-to-point network
`(config-if)# enable-ldp ipv4`	Enable LDP IPv4
`(config-if)# ip router isis ISIS-IGP`	Enable a routing process
`(config-if)#exit`	Exit interface mode
`(config-if)# router isis ISIS-IGP`	Enter the Router ISIS mode.
`(config-router)# is-type level-1`	IS Level for this routing process
`(config-router)# mpls traffic-eng router-id 22.22.22.22`	routing protocol commands for MPLS Traffic Engineering

(config-router)# net 49.0001.0000.0000.0006.00	Configure net
(config-router)#exit	Exit OSPF mode

BGP Configuration

(config)#router bgp	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 11.11.11.11 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 11.11.11.11 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 20.20.20.20 remote-as 65010	Configuring PE2 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 20.20.20.20 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 17.17.17.17 remote-as 65010	Configuring PE3 as I-BGP neighbor using it's loopback IP
(config-router)# neighbor 17.17.17.17 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 11.11.11.11 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 22.22.22.22 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 17.17.17.17 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf vrf400	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)# interface xe12.400 switchport	Configure static sub-interface
(config-if)# encapsulation dot1q 400	Configure encapsulation
(config-ig)# rewrite pop	Pop the outer VID
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 400	Map VPN-ID 400
(config-acc-if-evpn)# mac 0000.0000.aabb ip 40.40.1.20	Configure static mac with IP

(config-acc-if-evpn)# mac 0000.0000.bbaa ipv6 5001::20	Configure static mac with IPv6
(config-acc-if-evpn)#exit	Exiting out of access interface mode

P1

Loopback Interface:

#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 24.24.24.24/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)# router-id 24.24.24.24	Configure router id
(config-router)# transport-address ipv4 24.24.24.24	Configure transport address

Interface Configuration

(config)#interface xe2	Configure physical interface
(config-if)# mtu 9216	Configure MTU on the interface.
(config-if)# load-interval 30	Set load interval
(config-if)# ip address 30.30.30.2/24	Assign IP address
(config-if)# label-switching	Enable label switching
(config-if)# isis network point-to-point	Configure isis as point-to-point network
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe18	Configure physical interface
(config-if)# mtu 9216	Configure MTU on the interface.
(config-if)# load-interval 30	Set load interval
(config-if)# ip address 55.55.55.2/24	Assign IP address
(config-if)# label-switching	Enable label switching
(config-if)# isis network point-to-point	Configure isis as point-to-point network
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)#exit	Exit interface mode
(config)#interface xe40	Configure physical interface
(config-if)# mtu 9216	Configure MTU on the interface.

(config-if)# load-interval 30	Set load interval
(config-if)# ip address 76.76.76.2/24	Enter interface mode xe40
(config-if)# label-switching	Set label switching
(config-if)# isis network point-to-point	Set routing protocol isis
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#exit	Exit interface mode
(config-if)# mtu 1522	Configure MTU on the interface.
(config-if)#exit	Exit interface mode.
(config)# interface xe11	Create po subinterface
(config-if)# ip address 60.60.60.2/24	Assign IP address
(config-if)# mtu 9216	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# enable-ldp ipv4	Enable LDP IPv4
(config-if)# isis network point-to-point	Set routing protocol isis
(config-if)#exit	Exit interface mode

ISIS Configuration

(config)#router isis ISIS-IGP	Enter the Router IsIs mode.
(config-router)# is-type level-1	IS Level for this routing process
(config-router)# mpls traffic-eng router-id 24.24.24.24	routing protocol commands for MPLS Traffic Engineering
(config-router)# net 49.0001.0000.0000.0003.00	Configure net
(config-router)#exit	Exit Router isis mode and return to Configure mode.
(config)#commit	Commit candidate configuration to be running configuration

PE3

Enable EVPN MPLS and IRB

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 11.11.11.11/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

Configure MAC VRF

(config-vrf)#mac vrf green	Create MAC VRF mvrf4.
(config-vrf)# rd 11.11.11.11:400	Configure route distinguisher
(config-vrf)# route-target both 65010:400	Configure route target as evpn auto-rt(we can configure as manual RT also)
(config-vrf)#exit	Exit VRF mode

Configure IP VRF

(config)#ip vrf vrf400	Configure IP VRF vrf100.
(config-vrf)# rd 20:400	Configure route distinguisher
(config-vrf)# route-target both 100:400	Configure route target
(config-vrf)# l3vni 40000	Configure L3 VNID for routing
(config-vrf)#exit	Exit VRF mode

Configure Anycast Gateway MAC

(config)#evpn irb-forwarding anycastgateway- mac 0011.2233.4455	Configure anycast gateway MAC globally
(config)#interface irb500	Create IRB interface irb100
(config-irb-if)# ip vrf forwarding vrf400	Map L3 VRF to the IRB interface
(config-irb-if)# ip address 80.80.1.1/24 anycast	Assign IP address
(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac	Map anycast gateway MAC
(config-irb-if)#exit	Exit interface mode

Creating EVPN MPLS ID

(config)#evpn mpls vtep-ip-global 11.11.11.11	Configure VTEP global IP
(config)#evpn mpls id 500	Create EVPN MPLS ID
(config-evpn-mpls)# host-reachability-protocol evpn-bgp green	Map the MAC VRF mvrf4

(config-evpn-mpls)# evpn irb irb500	Map the IRB interface
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode

Global LDP

(config)#router ldp	Enter the Router LDP mode
(config-router)# transport-address ipv4 11.11.11.11	Configure LDP transport address
(config-router)#exit	Exit from LDP mode

Interface Configuration Network Side

(config-if)#interface xe27	Enter the Interface mode for eth10.
(config-if)# mtu 9216	Configure MTU.
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# ip address ip address 76.76.76.1/24	Assign IP address
(config-if)# mtu 1522	Configure MTU to the sub-if
(config-if)# label-switching	Enable label switching
(config-if)# isis network point-to-point	Configure isis as point-to-point network
(config-if)# router isis ISIS-IGP	Configure isis with ISIS-IGP area tag
(config-if)# exit	Exit interface mode

ISIS Configuration

(config)# router isis ISIS-IGP	Enter the Router ISIS mode.
(config-router)# is-type level-1	IS Level for this routing process
(config-router)# mpls traffic-eng router-id 11.11.11.11	Routing protocol commands for MPLS Traffic Engineering
(config-router)# net 49.0001.0000.0000.0005.00	Configure net

BGP Configuration

(config-router)# router bgp 65010	Enter the Router BGP mode, ASN: 65010
(config-router)# neighbor 20.20.20.20 remote-as 65010	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 20.20.20.20 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 22.22.22.22 remote-as 65010	Configuring PE2 as iBGP neighbor using it's loopback IP

(config-router)# neighbor 22.22.22.22 update-source lo lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 20.20.20.20 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 22.22.22.22 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf Vrf400	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)#interface po900	Create LAG interface po900
(config-if)# switchport	Configure as switchport
(config-if)# evpn multi-homed system-mac 0000.1111.aaaa	Configure system MAC for multi homing
(config)#interface po900.500 switchport	Creating L2 sub interface of physical interface xe28
(config-if)# encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 500	Map VPN-ID 500
(config-acc-if-evpn)#exit	Exiting out of access interface mode

PE4

Enable EVPN MPLS and IRB

#configure terminal	Enter configuration mode.
(config)#hardware-profile filter evpn-mpls-mh enable	Configure hardware profile to enable EVPN MPLS multi homing in hardware
(config)#evpn mpls enable	Enable EVPN MPLS globally
(config)#evpn mpls irb	Enable EVPN MPLS IRB globally
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming globally

Loopback Interface

(config-if)#interface lo	Enter the Interface mode for the loopback interface

`(config-if)# ip address 17.17.17/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

Configure MAC VRF

`(config-vrf)#mac vrf green`	Create MAC VRF mvrf4.
`(config-vrf)# rd 17.17.17.17:400`	Configure route distinguisher
`(config-vrf)# route-target both 65010:400`	Configure route target as evpn auto-rt (we can configure as manual RT also)
`(config-vrf)#exit`	Exit VRF mode

Configure IP VRF

`(config)#ip vrf vrf400`	Configure IP VRF vrf100.
`(config-vrf)# rd 10:400`	Configure route distinguisher
`(config-vrf)# route-target both 100:400`	Configure route target
`(config-vrf)# l3vni 40000`	Configure L3 VNID for routing
`(config-vrf)#exit`	Exit VRF mode

Configure Anycast Gateway MAC

`(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.5577`	Configure anycast gateway MAC globally

Configuring IRB interface

`(config)#interface irb500`	Create IRB interface irb100
`(config-irb-if)# ip vrf forwarding vrf400`	Map L3 VRF to the IRB interface
`(config-irb-if)# ip address 80.80.1.1/24 anycast`	Assign IP address
`(config-irb-if)# evpn irb-if-forwarding anycast-gateway-mac`	Map anycast gateway MAC
`(config-irb-if)#exit`	Exit interface mode

Creating EVPN MPLS ID

`(config)#evpn mpls vtep-ip-global 17.17.17.17`	Configure VTEP global IP
`(config)#evpn mpls id 500`	Create EVPN MPLS ID
`(config-evpn-mpls)# host-reachability-protocol evpn-bgp green`	Map the MAC VRF green

`(config-evpn-mpls)# evpn irb irb500`	Map the IRB interface
`(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode

Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 17.17.17.17`	Configure lo under ldp
`(config-router)#targeted-peer ipv4 20.20.20.20`	Configure targeted peer
`(config-router-targeted-peer)# exit-targeted-peer-mode`	Exit target peer mode
`(config-router)# targeted-peer ipv4 22.22.22.22`	Configure targeted peer
`(config-router-targeted-peer)# exit-targeted-peer-mode`	Exit target peer mode
`(config-router)# transport-address ipv4 17.17.17.17`	Configure LDP transport address
`(config-router)#exit`	Exit from LDP mode

Interface Configuration Network Side

`(config-if)#interface xe2`	Configure physical interface
`(config-if)# ip address 60.60.60.1/24`	Assign IP address
`(config-if)# mtu 9216`	Configure MTU to the sub-if
`(config-if)# label-switching`	Enable label switching
`(config-if)# isis network point-to-point`	Configure ISIS as point-to-point network
`(config-if)# ip router isis ISIS-IGP`	Configure ISIS with area tag ISIS-IGP
`(config-if)# enable-ldp ipv4`	Enable LDP IPv4
`(config-if)#exit`	Exit interface mode

ISIS Configuration

`(config)# router isis ISIS-IGP`	Enter the Router OSPF mode.
`(config-router)# is-type level-1`	Configure routing ISIS level
`(config-router)# mpls traffic-eng router-id 17.17.17.17`	Routing protocol commands for MPLS Traffic Engineering.
`(config-router)# net 49.0001.0000.0000.0004.00`	Configure net

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BGP Configuration

(config)#router bgp 65010	Enter the Router BGP mode, ASN: 100
(config-router)# bgp router-id 17.17.17.17	
(config-router)# neighbor 20.20.20.20 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 20.20.20.20 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 22.22.22.22 remote-as 65010	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 22.22.22.21 update-source lo	Source of routing updates as loopback
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 20.20.20.20 activate	Enabling EVPN Address family for neighbor
(config-router-af)# neighbor 22.22.22.22 activate	Enabling EVPN Address family for neighbor
(config-router-af)# exit-address-family	Exiting of Address family mode
(config-router)# address-family ipv4 vrf Vrf500	Entering into VRF address family mode
(config-router-af)# redistribute connected	Redistribute connected routes to the network
(config-router-af)# exit-address-family	Exiting of Address family mode

Access Port Configuration

(config)#interface po900	Create LAG interface po1
(config-if)# switchport	Configure as switchport
(config-if)# evpn multi-homed system-mac 0000.0000.1111	Configure system MAC for multi homing
(config)#interface po900.500 switchport	Creating L2 sub interface of physical interface xe9
(config-if)# encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 500	Map VPN-ID 500
(config-acc-if-evpn)#exit	Exiting out of access interface mode

Validation

PE1

```
SH-1-7020#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
```

```
===================================================================================
20.20.20.20      17.17.17.17      Installed     17:04:56      17:04:56      701
20.20.20.20      17.17.17.17      Installed     17:04:56      17:04:56      700
20.20.20.20      17.17.17.17      Installed     17:04:56      17:04:56      600
20.20.20.20      17.17.17.17      Installed     21:39:09      21:39:09      40000
20.20.20.20      22.22.22.22      Installed     21:39:09      21:39:09      40000
20.20.20.20      22.22.22.22      Installed     13:59:58      13:59:58      400
20.20.20.20      11.11.11.11      Installed     17:04:56      17:04:56      701
20.20.20.20      11.11.11.11      Installed     17:04:56      17:04:56      700
20.20.20.20      11.11.11.11      Installed     17:04:56      17:04:56      600
20.20.20.20      11.11.11.11      Installed     17:04:56      17:04:56      400
20.20.20.20      11.11.11.11      Installed     21:39:09      21:39:09      40000

Total number of entries are 11
SH-1-7020#show evpn mpls mac-table
=======================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
=======================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI              Type
Status     MAC move AccessPortDesc
_______________________________________________________________________________________
__________________________________________________

400        irb400    ----      ----      0011.2233.5577 20.20.20.20
Static Local    -------    0        -------
400        sa10000.400 ----      ----      0000.0000.aaaa 20.20.20.20
Static Local    -------    0        -------
400        sa10000.400 ----      ----      0000.0000.bbbb 20.20.20.20
Static Local    -------    0        -------

Total number of entries are: 3
SH-1-7020#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
400      40.40.1.1       0011.2233.5577 Static Local   ----
400      40.40.1.10      0000.0000.aaaa Static Local   ----
Total number of entries are 2
SH-1-7020#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
==============================
EVPN-ID  Ip-Addr                       Mac-Addr         Type         Age-Out   Retries-
Left
_______________________________________________________________________________________
______
400      5001::1                        0011.2233.5577 Static Local     ----
400      5001:aaaa::1                   0000.0000.bbbb Static Local     ----
Total number of entries are 2
SH-1-7020#show bgp l2vpn evpn multihoming ethernet-ad-per-es
```

```
RD[11.11.11.11:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  38             11.11.11.11     MPLS

RD[17.17.17.17:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  37             17.17.17.17     MPLS
```

PE2

```
SH2-7022#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=======================================================================================
22.22.22.22      11.11.11.11      Installed     14:21:58      14:21:58      400
22.22.22.22      11.11.11.11      Installed     19:56:30      19:56:30      40000
22.22.22.22      17.17.17.17      Installed     19:56:30      19:56:30      40000
22.22.22.22      20.20.20.20      Installed     14:30:31      14:30:31      400
22.22.22.22      20.20.20.20      Installed     19:56:30      19:56:30      40000

Total number of entries are 5
SH2-7022#show evpn mpls mac-table
=========================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
=========================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc
_________________________________________________________________________________________
__________________________________________________

400        irb400    ----       ----      0011.2233.5577 22.22.22.22
Static Local    -------    0        -------
400        ----      ----       ----      0000.0000.aaaa 20.20.20.20
Static Remote   -------    0        -------
400        ----      ----       ----      0000.0000.bbbb 20.20.20.20
Static Remote   -------    0        -------

Total number of entries are : 3
SH2-7022#sh evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
400      40.40.1.1        0011.2233.5577 Static Local   ----
400      40.40.1.10       0000.0000.aaaa Static Remote  ----
Total number of entries are 2

SH2-7022#sh evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
==============================
```

```
EVPN-ID  Ip-Addr                       Mac-Addr         Type         Age-Out   Retries-
Left
_____________________________________________________________________________________
______
400      5001::1                        0011.2233.5577 Static Local     ----
400      5001:aaaa::1                   0000.0000.bbbb Static Remote    ----
Total number of entries are 2

SH2-7022#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[11.11.11.11:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  38             11.11.11.11     MPLS

RD[17.17.17.17:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  37             17.17.17.17     MPLS

SH2-7022#sh bgp l2vpn evpn
BGP table version is 11, local router ID is 22.22.22.22
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network        Next Hop          Metric    LocPrf      Weight     Path  Peer
Encap

RD[10:400]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     17.17.17.17         0       100       0    ?  17.17.17.17     MPLS

RD[20:400]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                     11.11.11.11         0       100       0    ?  11.11.11.11     MPLS

RD[30:400]
*>i  [5]:[0]:[0]:[24]:[40.40.1.0]:[0.0.0.0]:[16]
                     20.20.20.20         0       100       0    ?  20.20.20.20     MPLS

RD[11.11.11.11:400]
*>i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[18]
                     11.11.11.11         0       100       0    i  11.11.11.11     MPLS
*>i  [3]:[400]:[32,11.11.11.11]
```

```
                     11.11.11.11         0        100       0    i  11.11.11.11     MPLS
*>i  [3]:[500]:[32,11.11.11.11]
                     11.11.11.11         0        100       0    i  11.11.11.11     MPLS

RD[17.17.17.17:400]
*>i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[17]
                     17.17.17.17         0        100       0    i  17.17.17.17     MPLS
*>i  [3]:[500]:[32,17.17.17.17]
                     17.17.17.17         0        100       0    i  17.17.17.17     MPLS

RD[17.17.17.17:600]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[600]:[18]
                     17.17.17.17         0        100       0    i  17.17.17.17     MPLS
*>i  [3]:[600]:[32,17.17.17.17]
                     17.17.17.17         0        100       0    i  17.17.17.17     MPLS

RD[20.20.20.20:400]
*>i  [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
*>i  [3]:[400]:[32,20.20.20.20]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS

RD[20.20.20.20:600]
*>i  [3]:[600]:[32,20.20.20.20]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS

RD[20.20.20.20:700]
*>i  [3]:[0]:[32,20.20.20.20]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS

RD[20.20.20.20:701]
*>i  [2]:[0]:[701]:[48,0000:0000:2001]:[0]:[29]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[701]:[48,0000:0000:2002]:[32,20.20.20.1]:[29]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[701]:[48,0000:0000:2003]:[128,1204::1]:[29]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
*>i  [3]:[701]:[32,20.20.20.20]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS

RD[22.22.22.22:400] VRF[green]:
* i  [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]
                     20.20.20.20         0        100       0    i  20.20.20.20     MPLS
* i  [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]
```

```
                      20.20.20.20         0        100       0    i  20.20.20.20    MPLS
*>   [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
                       22.22.22.22         0        100       32768  i  ----------
MPLS
* i                   20.20.20.20         0        100       0    i  20.20.20.20    MPLS
*>   [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
                       22.22.22.22         0        100       32768  i  ----------
MPLS
* i                   20.20.20.20         0        100       0    i  20.20.20.20    MPLS
* i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[18]
                      11.11.11.11         0        100       0    i  11.11.11.11    MPLS
* i                   17.17.17.17         0        100       0    i  17.17.17.17    MPLS
* i  [3]:[400]:[32,11.11.11.11]
                      11.11.11.11         0        100       0    i  11.11.11.11    MPLS
* i  [3]:[400]:[32,20.20.20.20]
                      20.20.20.20         0        100       0    i  20.20.20.20    MPLS
*>   [3]:[400]:[32,22.22.22.22]
                       22.22.22.22         0        100       32768  i  ----------
MPLS
* i  [3]:[500]:[32,11.11.11.11]
                      11.11.11.11         0        100       0    i  11.11.11.11    MPLS
* i  [3]:[500]:[32,17.17.17.17]
                      17.17.17.17         0        100       0    i  17.17.17.17    MPLS

Total number of prefixes 50
```

PE3

```
MH-2-7011#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down        Update         evpn-id
==================================================================================
11.11.11.11      22.22.22.22      Installed      15:23:05       15:23:05       400
11.11.11.11      22.22.22.22      Installed      23:11:42       23:11:42       40000
11.11.11.11      17.17.17.17      Installed      18:36:34       18:36:34       500
11.11.11.11      17.17.17.17      Installed      23:11:42       23:11:42       40000
11.11.11.11      20.20.20.20      Installed      18:36:34       18:36:34       400
11.11.11.11      20.20.20.20      Installed      23:11:42       23:11:42       40000

MH-2-7011#show evpn mpls mac-table
======================================================================================
==================================================
                                                     EVPN MPLS MAC Entries
======================================================================================
==================================================
VNID     Interface VlanId   In-VlanId Mac-Addr     VTEP-Ip/ESI             Type
Status     MAC move AccessPortDesc

______________________________________________________________________________________
__________________________________________________

400        ----      ----      ----      0011.2233.5577 20.20.20.20
Static Remote   -------    0        -------
```

```
400       ----      ----      ----      0000.0000.aaaa 20.20.20.20
Static Remote   -------    0        -------
400       ----      ----      ----      0000.0000.bbbb 20.20.20.20
Static Remote   -------    0        -------
500       irb500    ----      ----      0011.2233.5577 11.11.11.11
Static Local    -------    0        -------

MH-2-7011#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
400      40.40.1.1        0011.2233.5577 Static Remote  ----
400      40.40.1.10       0000.0000.aaaa Static Remote  ----
500      80.80.1.1        0011.2233.5577 Static Local   ----
Total number of entries are 3
MH-2-7011#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
==============================
EVPN-ID  Ip-Addr                       Mac-Addr         Type        Age-Out   Retries-
Left
________________________________________________________________________________________
______
400      5001::1                        0011.2233.5577 Static Remote    ----
400      5001:aaaa::1                   0000.0000.bbbb Static Remote    ----
Total number of entries are 2

MH-2-7011#show bgp l2vpn evpn multihoming ethernet-ad-per-es


RD[11.11.11.11:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  38             11.11.11.11     MPLS

RD[17.17.17.17:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap
00:00:00:11:11:aa:aa:00:00:00  4294967295  37             17.17.17.17     MPLS
MH-2-7011#sh bgp l2vpn evpn
BGP table version is 8, local router ID is 11.11.11.11
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route
```

```
   Network         Next Hop          Metric    LocPrf      Weight     Path  Peer
Encap

RD[10:400]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                    17.17.17.17         0        100        0    ?  17.17.17.17     MPLS

RD[30:400]
*>i  [5]:[0]:[0]:[24]:[40.40.1.0]:[0.0.0.0]:[16]
                    20.20.20.20         0        100        0    ?  20.20.20.20     MPLS

RD[40:400]
*>i  [5]:[0]:[0]:[24]:[40.40.1.0]:[0.0.0.0]:[16]
                    22.22.22.22         0        100        0    ?  22.22.22.22     MPLS

RD[11.11.11.11:400] VRF[green]:
* i  [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]
                    20.20.20.20         0        100        0    i  20.20.20.20     MPLS
* i  [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]
                    20.20.20.20         0        100        0    i  20.20.20.20     MPLS
* i  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
                    22.22.22.22         0        100        0    i  22.22.22.22     MPLS
* i                 20.20.20.20         0        100        0    i  20.20.20.20     MPLS
* i  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
                    22.22.22.22         0        100        0    i  22.22.22.22     MPLS
* i                 20.20.20.20         0        100        0    i  20.20.20.20     MPLS
* i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[17]
                    17.17.17.17         0        100        0    i  17.17.17.17     MPLS
*>                   11.11.11.11         0        100      32768  i  ----------
MPLS
*>   [3]:[400]:[32,11.11.11.11]
                     11.11.11.11         0        100      32768  i  ----------
MPLS
* i  [3]:[400]:[32,20.20.20.20]
                    20.20.20.20         0        100        0    i  20.20.20.20     MPLS
* i  [3]:[400]:[32,22.22.22.22]
                    22.22.22.22         0        100        0    i  22.22.22.22     MPLS
*>   [3]:[500]:[32,11.11.11.11]
                     11.11.11.11         0        100      32768  i  ----------
MPLS
* i  [3]:[500]:[32,17.17.17.17]
                    17.17.17.17         0        100        0    i  17.17.17.17     MPLS


RD[11.11.11.11:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     11.11.11.11         0        100      32768  i  ----------
MPLS
*>   [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,11.11.11.11]
                     11.11.11.11         0        100      32768  i  ----------
MPLS
* i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,17.17.17.17]
```

```
                     17.17.17.17          0        100       0    i  17.17.17.17     MPLS

RD[17.17.17.17:400]
*>i  [2]:[0]:[500]:[48,0011:2233:5577]:[32,80.80.1.1]:[17]
                     17.17.17.17          0        100       0    i  17.17.17.17     MPLS
*>i  [3]:[500]:[32,17.17.17.17]
                     17.17.17.17          0        100       0    i  17.17.17.17     MPLS


RD[17.17.17.17:64512]
*>i  [1]:[00:00:00:11:11:aa:aa:00:00:00]:[4294967295]:[0]
                     17.17.17.17          0        100       0    i  17.17.17.17     MPLS
*>i  [4]:[00:00:00:11:11:aa:aa:00:00:00]:[32,17.17.17.17]
                     17.17.17.17          0        100       0    i  17.17.17.17     MPLS

RD[20.20.20.20:400]
*>i  [2]:[0]:[400]:[48,0000:0000:aaaa]:[32,40.40.1.10]:[17]:[16]
                     20.20.20.20          0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[400]:[48,0000:0000:bbbb]:[128,5001:aaaa::1]:[17]
                     20.20.20.20          0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
                     20.20.20.20          0        100       0    i  20.20.20.20     MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
                     20.20.20.20          0        100       0    i  20.20.20.20     MPLS
*>i  [3]:[400]:[32,20.20.20.20]
                     20.20.20.20          0        100       0    i  20.20.20.20     MPLS

RD[22.22.22.22:400]
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[32,40.40.1.1]:[17]
                     22.22.22.22          0        100       0    i  22.22.22.22     MPLS
*>i  [2]:[0]:[400]:[48,0011:2233:5577]:[128,5001::1]:[17]
                     22.22.22.22          0        100       0    i  22.22.22.22     MPLS
*>i  [3]:[400]:[32,22.22.22.22]
                     22.22.22.22          0        100       0    i  22.22.22.22     MPLS
```

PE4

```
MH-1-7017#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
17.17.17.17      22.22.22.22      Installed     1d00h04m      1d00h04m      40000
17.17.17.17      11.11.11.11      Installed     00:20:45      00:20:45      500
17.17.17.17      11.11.11.11      Installed     1d00h04m      1d00h04m      40000
17.17.17.17      20.20.20.20      Installed     1d00h04m      1d00h04m      40000

MH-1-7017#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
==============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
```

```
_____________________________________________________________________________
500      80.80.1.1        0011.2233.5577 Static Local   ----
Total number of entries are 1
```

CHAPTER 3 EVPN Active-Standby

Overview

EVPN Multihoming is a mechanism that allows a host or customer edge (CE) device to be connected to multiple Provider Edge (PE) devices called Multihoming (MH) peers for redundancy and load balancing purposes. This provides high availability and resiliency to the network, ensuring continuous connectivity even in case of a PE device failure.

Note: OcNOS support extends to a maximum of two MH peers.

Multihoming supports two kinds of redundancy, namely 1. All Active 2. Active-Standby.

Till now, OcNOS support All-Active (A-A) only. In OcNOS version 6.4.1, Port-Active mode is supported and in OcNOS version 6.4.2, Single-Active mode is supported in the context of Active-Standby redundancy.

Single-Active

- In this mode, traffic for a specific host or MAC address is handled by only one of the PE devices (MH peers) at a time.
- The other PE devices remain in standby mode, ready to take over if the active PE fails.
- The physical link state (either Physical port or LACP port) on the standby PE remains up, enabling a faster transition to the active role in the event of a failover. The CE devices use different interfaces, including LACP or physical connections, to connect to the Peer MH devices.

Port-Active

- In this mode, traffic for a specific host or MAC address is handled by only one of the PE devices (MH peers) at a time.
- Each MH peer connects through LACP with the same key as the CE devices (similar to A-A redundancy).
- The physical link state (LACP port) on the standby PE is made down, effectively blocking traffic on those ports.
- If a failover occurs, the standby PE must bring up its LACP ports to start forwarding traffic.

IRB Active-Standby: Active-standby mode is also applicable to Integrated Routing and Bridging (IRB) for both L3VPN symmetric and asymmetric modes.

Feature Characteristics

Single-Active standby redundancy mechanisms support both ELAN and ELINE services.

Single-Active ELINE

ELINE refers to Ethernet Line services, where two PEs are cross-connected to each other over an Ethernet link.

In Single-Active ELINE, the primary objective is to achieve redundancy for hosts while also using the same link for data exchange until it fails, at which point it should switch to the secondary or standby link. Here's how it works:

- **MH Host Traffic**
  - One of the PE devices (MH peers) acts as the “Active” for the Attachment Circuit (AC) associated with the host. This PE sends and receives traffic to and from the host.
  - The other PE acts as the “Standby” for the same AC and does not allow traffic to or from the host.

  - The standby PE, despite receiving BUM traffic from the Host device (which is unaware of the cross-connect), blocks this traffic at the standby PE itself, as it operates in a standby role for the AC. Conversely, the active PE allows the flow of traffic.
- **Remote Host Traffic:** Traffic originating from remote hosts destined for the multihomed host is only sent to the active MH peer for the corresponding AC. This ensures that the cross connect is established only with the Active MH peer.

Single-Active ELAN

ELAN stands for Ethernet LAN services, where a group of PEs are interconnected in a multipoint Ethernet network.

In Single-Active ELAN, similar to Single-Active ELINE, redundancy for hosts and data exchange over the primary link are priorities, but there are some specific differences for Ethernet LAN (ELAN) scenarios:

- **MH Host Traffic**
  - One of the PE devices (MH peers) is designated as the “Active” for the AC associated with the host. This PE handles sending and receiving traffic to and from remote locations.
  - The other PE acts as the “Standby” role for the same AC. It receives BUM traffic from the host but blocks the traffic. Additionally, it refrains from learning MAC addresses and does not uplift Address Resolution Protocol/ Neighbor Discovery (ARP/ND) packets.
  - Unicast traffic from the host will be directed to the active PE, which will then allow the traffic to be sent across the network.
- **Remote Host Unicast Traffic:** Unicast traffic from remote hosts destined for the multihomed host is sent only to the active MH peer for the corresponding AC. This is because the MAC addresses of the host are learned only from the Active MH peer.
- **Remote Host BUM Traffic:** BUM traffic, such as broadcast and multicast packets from the remote PE device, is replicated to both MH PEs. However, only the active PE, which is also designated as a forwarder, allows this traffic to reach the host. The standby PE, classified as a Non-Designated Forwarder, drops the egress traffic.

Port-Active Ethernet LAN (ELAN) and Ethernet LINE (ELINE) are examples of port-active standby redundancy mechanisms.

Port-Active ELINE

Port-Active ELINE enables redundancy and optimized data exchange by designating an active port for traffic handling in multihomed network setups. Here's how it works:

- **Active AC Link:** Among the Multihomed (MH) peers, a designated PE is assigned as “Active” for the AC associated with the host. This PE manages bidirectional traffic to and from the host. In a port-active configuration, all hosts associated with the ESI link remain in the same state, as the Active and Standby status is determined per ESI link.
- **Standby AC Link:** The AC link attached to the host, designated as “Standby,” remains operationally down. It serves as a backup link for failover scenarios.
- **MH Host traffic:** BUM and unicast traffic from the host are always directed towards the Active PE because the link towards the Active PE is operational UP. Conversely, the link towards the Standby PE from the host devices is operational DOWN.
- **Remote Host Traffic:** Traffic originating from remote hosts and destined for the multihomed host is directed exclusively to the Active MH node that serves the corresponding AC. This ensures efficient traffic routing and intelligent cross-connection establishment.

Port-Active ELAN

Port-Active ELAN enhances redundancy and efficient data exchange by designating an active port for traffic management in multihomed Ethernet LAN environments. Here's how it works:

- **Active AC Link:** Within the MH peers, one PE is identified as the "Active" entity for the AC. It manages traffic to and from remote locations efficiently.
- **Standby AC Link:** Similar to Port-Active ELINE, the standby AC link attached to the host remains operationally down to ensure effective standby redundancy.
- **MH Host Traffic:** In a port-active scenario, the standby link does not receive any traffic from the host. Only the active link manages incoming traffic from the host. The Active PE also learns and advertises host information to remote locations, including MAC addresses and ARP/ND details.
- **Remote Host Unicast Traffic:** Unicast traffic from remote sources is directed exclusively to the Active MH PE that has advertised the host address, optimizing traffic flow.
- **Remote Host BUM Traffic:** BUM traffic is replicated across all MH nodes. However, egress traffic for BUM packets occurs only from the Active PE. The standby PE drops the traffic since the AC links are operational DOWN.

Benefits

The benefits of Single-Active and Port-Active include enhanced redundancy and fault tolerance for hosts and customer edge devices, efficient data exchange, minimized downtime, and improved network resiliency in multihomed Ethernet Line and Ethernet LAN environments. These mechanisms ensure uninterrupted connectivity and optimized traffic management, contributing to higher availability and improved user experience.

Prerequisites

Here are the prerequisites for configuring EVPN Multihoming:

Ensure EVPN Configuration: Make sure that the EVPN is configured already in the network as it is a requirement for EVPN Multihoming.

Configure Attachment Circuits (AC): Ensure that each CE device is appropriately linked to the PE devices through Attachment Circuits. These circuits must be configured correctly.

Set Up LACP Configuration: To use Link Aggregation Control Protocol (LACP) for multihoming, configure LACP appropriately on the relevant interfaces.

EVPN MPLS Global Configuration: To enable EVPN MPLS features, need to configure global settings, such as enabling EVPN MPLS, defining global VTEP IP addresses, enabling hardware profile filtering for multihoming, and activating EVPN MPLS multihoming functionality. These settings are essential for EVPN and MPLS operation.

Access Port Configuration: Depending on the network's redundancy plan (single-active or port-active), configure access ports, including parameters for load balancing, service carving preferences, and EVPN settings. These configurations are crucial for network access and connectivity in an EVPN environment.

These prerequisites ensure that the network is ready for the implementation of EVPN Multihoming, providing redundancy and load balancing for CE devices.

Configuration

Here are sample configurations for EVPN MPLS Active-Standby MultiHoming Configuration and EVPN SR Active-Standby Multi-Homing Configuration, including topology, configuration procedures, and corresponding validations.

For more information on the EVPN MPLS configurations, see the EVPN MPLS Configuration and EVPN MPLS IRB Configuration chapters in the *Multi-Protocol Label Switching Guide*.

EVPN MPLS Active-Standby MultiHoming Configuration

This section illustrates the Multi-Homed setup for the EVPN MPLS Active-Standby configuration, showcasing examples for both ELINE and ELAN services with LDP as the underlay MPLS path.

EVPN MPLS Active-Standby MH Topology

Figure 3-7 consists of customer edge routers CE1 and CE2, along with IPv4 Provider Edge routers PE1, PE2, PE3, and PE4, all interconnected through the core routers P1 and P2 in the IPv4 MPLS provider network.

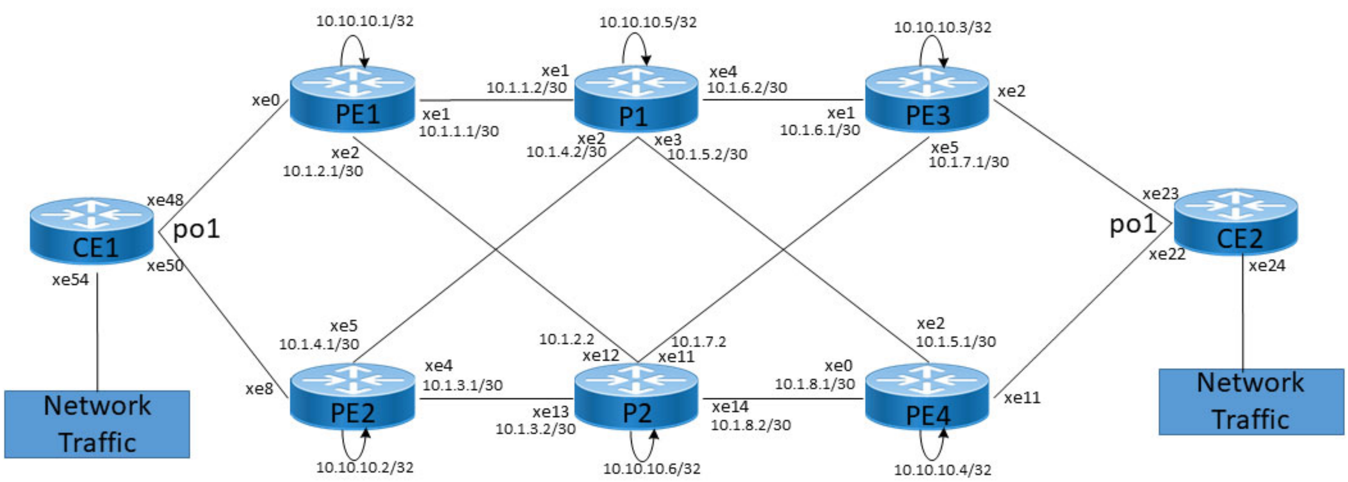

Figure 3-7: EVPN MPLS AS MH Configuration

CE1

The following configuration steps under CE1 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

`CE1#configure terminal`	Enter configure mode.
`CE1(config)#bridge 1 protocol ieee vlan-bridge`	Set up `bridge 1` to use the IEEE VLAN bridge protocol.
`CE1(config)#vlan 2-100 bridge 1 state enable`	Configure VLANs from `2-100` and associate them with bridge 1.
`CE1(config)#interface xe54`	Enter interface mode `xe54`.
`CE1(config-if)#switchport`	Configure the interface `xe54` as a Layer 2 switch port.
`CE1(config-if)#bridge-group 1`	Associate `xe54` to bridge 1.
`CE1(config-if)#switchport mode trunk`	Configure `xe54` as a trunk port.
`CE1(config-if)#switchport trunk allowed vlan all`	Allow all configured VLANs on the trunk interface `xe54`.
`CE1(config-if)#exit`	Exit interface mode `xe54`.
`CE1(config)#interface po1`	Enter interface mode and configure LAG interface port-channel 1 (`po1`).
`CE1(config-if)#switchport`	Configures port-channel 1 as a Layer 2 switch port.

CE1(config-if)#bridge-group 1	Associate po1 to bridge 1.
CE1(config-if)#switchport mode trunk	Configure po1 as a trunk port.
CE1(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk port-channel po1.
CE1(config-if)#exit	Exit interface mode po1.
CE1(config)#interface xe48	Enter interface mode xe48.
CE1(config-if)#lacp timeout short	Configure LACP timeout as short.
CE1(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE1(config-if)#exit	Exit interface mode xe48.
CE1(config-if)#interface xe50	Enter interface mode xe50.
CE1(config-if)#lacp timeout short	Configure LACP timeout as short.
CE1(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE1(config-if)#commit	Commit the transaction.
CE1(config-if)#end	Exit interface mode xe50 and configure mode.

PE1: Loopback Interface

The configuration on PE1 for a loopback interface with IP address 10.10.10.1/32 secondary is set up to provide IP connectivity for the router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE1(config-if)#ip address 10.10.10.1/32 secondary	Configure a secondary IP address, 10.10.10.1/32, on the loopback interface.
PE1(config-if)#exit	Exit interface mode lo.
PE1(config)#commit	Commit the transaction.

PE1: Global LDP

The configuration on PE1 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE1(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.10.10.1	Set the router ID for LDP to 10.10.10.1.
PE1(config-router)#transport-address ipv4 10.10.10.1	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE1(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

The configuration on PE1 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE1(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE1, enabling it to participate in EVPN MPLS services.
PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#evpn mpls vtep-ip-global 10.10.10.1	Configure the global VTEP IP address 10.10.10.1, associating it with the loopback IP.
PE1(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE1(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE1 to support multi-homed EVPN MPLS services.
PE1(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE1(config)#interface xe1	Enter interface mode xe1.
PE1(config-if)#ip address 10.1.1.1/30	Configure an IP address, 10.1.1.1/30, on the interface xe1.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#exit	Exit interface mode xe1.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface xe2	Enter interface mode xe2.
PE1(config-if)#ip address 10.1.2.1/30	Configure an IP address, 10.1.2.1/30, on the interface xe2.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

`PE1(config-if)#exit`	Exit interface mode `xe2`.
`PE1(config)#commit`	Commit the transaction.

PE1: OSPF Configuration

The below configuration is performed to set up OSPF on PE1, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

`PE1(config)#router ospf 100`	Enter the router OSPF mode. Configure PE1 to run OSPF with process ID 100.
`PE1(config-router)#ospf router-id 10.10.10.1`	Set the OSPF router ID to `10.10.10.1`, identifying PE1 within the OSPF network.
`PE1(config-router)#network 10.10.10.1/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`PE1(config-router)#network 10.1.1.1/30 area 0.0.0.0`	Advertise network address in OSPF.
`PE1(config-router)#network 10.1.2.1/30 area 0.0.0.0`	Advertise network address in OSPF.
`PE1(config-router)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval with an interval of `3`, a minimum receive interval of `3`, and a multiplier of `3`.
`PE1(config-router)#exit`	Exit router OSPF mode and return to configure mode.
`PE1(config)#commit`	Commit the transaction.

PE1: BGP Configuration

The below BGP configuration on PE1 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

`PE1(config)#router bgp 65010`	Enter the Router BGP mode, ASN: 65010
`PE1(config-router)#bgp router-id 10.10.10.1`	Configure BGP router ID `10.10.10.1`, identifying PE1 within the BGP network.
`PE1(config-router)#neighbor 10.10.10.2 remote-as 65010`	Configure neighbor `10.10.10.2` as an iBGP neighbor with their remote AS number `65010`.
`PE1(config-router)#neighbor 10.10.10.2 update-source lo`	Configure neighbor `10.10.10.2` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#neighbor 10.10.10.3 remote-as 65010`	Configure neighbor `10.10.10.3` as an iBGP neighbor with their remote AS number `65010`.
`PE1(config-router)#neighbor 10.10.10.3 update-source lo`	Configure neighbor `10.10.10.3` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#neighbor 10.10.10.4 remote-as 65010`	Configure neighbor `10.10.10.4` as an iBGP neighbor with their remote AS number `65010`.
`PE1(config-router)#neighbor 10.10.10.4 update-source lo`	Configure neighbor `10.10.10.4` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#neighbor 10.10.10.2 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.

`PE1(config-router)#neighbor 10.10.10.3 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE1(config-router)#neighbor 10.10.10.4 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE1(config-router)#neighbor 10.10.10.2 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE1(config-router)#neighbor 10.10.10.3 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE1(config-router)#neighbor 10.10.10.4 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE1(config-router)#address-family l2vpn evpn`	Enter into address family mode for L2VPN EVPN.
`PE1(config-router-af)#neighbor 10.10.10.2 activate`	Activate EVPN for iBGP neighbor `10.10.10.2` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#neighbor 10.10.10.3 activate`	Activate EVPN for iBGP neighbor `10.10.10.3` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#neighbor 10.10.10.4 activate`	Activate EVPN for iBGP neighbor `10.10.10.4` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#exit`	Exit address family mode and return to the router BGP mode.
`PE1(config-router)#commit`	Commit the transaction.
`PE1(config-router)#exit`	Exit router BGP mode and return to the configure mode.

PE1: MAC VRF Configuration

The below MAC VRF configuration on PE1 is carried out to define and set up VRFs named `vrf2` and `vpls1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

`PE1(config)#mac vrf vrf2`	Enter VRF mode named `vrf2`.
`PE1(config-vrf)#rd 10.10.10.1:1700`	Configure Route-Distinguisher value of `10.10.10.1:1700`.
`PE1(config-vrf)#route-target both 1700:1700`	Configure import and export values for the `vrf2` as `1700:1700`.
`PE1(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE1(config)#mac vrf vpls1001`	Enter VRF mode named `vpls1001`.
`PE1(config-vrf)#rd 10.10.10.1:1001`	Configure Route-Distinguisher value of `10.10.10.1:1001`.
`PE1(config-vrf)#route-target both 1001:1001`	Configure import and export values for the `vpls1001` as `1001:1001`.
`PE1(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE1(config)#commit`	Commit the transaction.

PE1: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE1 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE1(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with a source identifier of 1800 and a target identifier of 1700.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE1(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE1 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE1(config)#interface po1	Enter the port channel interface mode for po1
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active	Configure the system-mac address 0000.1111.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE1(config-if-es)#service-carving auto	Configure service carving as auto.
PE1(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE1(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE1(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE1(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE1(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE1(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE1(config)#interface xe0	Enter the interface mode for xe0.
PE1(config-if)#speed 10g	Set the speed to 10g.
PE1(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE1(config-if)#exit	Exit interface mode xe0 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE1 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

`PE1(config)#interface sa1`	Enter the single active interface mode for `sa1`
`PE1(config-if)#load-interval 30`	Set the load interval to `30`.
`PE1(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active`	Configure the ESI with the value with the value `00:00:11:11:77:77` for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE1(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE1(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE1(config-if)#exit`	Exit interface mode `sa1` and return to the configure mode.
`PE1(config)#commit`	Commit the transaction.
`PE1(config)#interface sa1.1 switchport`	Create a Layer 2 sub-interface `sa1.1` within the port channel.
`PE1(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE1(config-if)#load-interval 30`	Set the load interval to `30`.
`PE1(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE1(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE1(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE1(config-if)#exit`	Exit interface mode `sa1.1` and return to the configure mode.
`PE1(config)#interface xe0`	Enter the interface mode for `xe0`.
`PE1(config-if)#speed 10g`	Set the speed to `10g`.
`PE1(config-if)#static-channel-group 1`	Attach the static-channel-group 1, the LAG interface `sa1` to `xe0`.
`PE1(config-if)#exit`	Exit interface mode `xe0` and return to the configure mode.
`PE1(config)#commit`	Commit the transaction.

PE2: Loopback Interface

The configuration on PE2 for a loopback interface with IP address `10.10.10.2/32` secondary is set up to provide IP connectivity for the router.

`PE2#configure terminal`	Enter configure mode.
`PE2(config)#interface lo`	Enter the interface mode for the loopback interface `lo`.
`PE2(config-if)#ip address 10.10.10.2/32 secondary`	Configure a secondary IP address, `10.10.10.2/32`, on the loopback interface.
`PE2(config-if)#exit`	Exit interface mode `lo`.
`PE2(config)#commit`	Commit the transaction.

PE2: Global LDP

The configuration on PE2 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

`PE2(config)#router ldp`	Enter the Router LDP mode.
`PE2(config-router)#router-id 10.10.10.2`	Set the router ID for LDP to `10.10.10.2`.
`PE2(config-router)#transport-address ipv4 10.10.10.2`	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
`PE2(config-router)#targeted-peer ipv4 10.10.10.1`	Configure targeted peer for LDP using IPv4 addresses.
`PE2(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit router targeted-peer-mode.
`PE2(config-router)#targeted-peer ipv4 10.10.10.3`	Configure targeted peer for LDP using IPv4 addresses.
`PE2(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit router targeted-peer-mode.
`PE2(config-router)#targeted-peer ipv4 10.10.10.4`	Configure targeted peer for LDP using IPv4 addresses.
`PE2(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit router targeted-peer-mode.
`PE2(config-router)#exit`	Exit router LDP mode and return to the configure mode.
`PE2(config)#commit`	Commit the transaction.

PE2: Global EVPN MPLS Command

The configuration on PE2 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

`PE2(config)#evpn mpls enable`	Activate the EVPN MPLS functionality on `PE2`, enabling it to participate in EVPN MPLS services.
`PE2(config)#commit`	Commit candidate configuration to be running configuration.
`PE2(config)#evpn mpls vtep-ip-global 10.10.10.2`	Configure the global VTEP IP address `10.10.10.2`, associating it with the loopback IP.
`PE2(config)#hardware-profile filter evpn-mpls-mh enable`	Enable hardware-profile filter for EVPN MPLS multi-homing.
`PE2(config)#evpn mpls multihoming enable`	Activate the EVPN MPLS multi-homing functionality, allowing `PE2` to support multi-homed EVPN MPLS services.
`PE2(config)#commit`	Commit the transaction.

PE2: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

`PE2(config)#interface xe4`	Enter interface mode `xe4`.
`PE2(config-if)#ip address 10.1.3.1/30`	Configure an IP address, `10.1.3.1/30`, on the interface `xe4`.
`PE2(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`PE2(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`PE2(config-if)#exit`	Exit interface mode `xe4`.
`PE2(config)#commit`	Commit the transaction.
`PE2(config)#interface xe5`	Enter interface mode `xe5`.
`PE2(config-if)#ip address 10.1.4.1/30`	Configure an IP address, `10.1.4.1/30`, on the interface `xe5`.
`PE2(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`PE2(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`PE2(config-if)#exit`	Exit interface mode `xe5`.
`PE2(config)#commit`	Commit the transaction.

PE2: OSPF Configuration

The below configuration is performed to set up OSPF on PE2, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

`PE2(config)#router ospf 100`	Enter the router OSPF mode. Configure PE2 to run OSPF with process ID 100.
`PE2(config-router)#ospf router-id 10.10.10.2`	Set the OSPF router ID to `10.10.10.2`, identifying PE2 within the OSPF network.
`PE2(config-router)#network 10.1.3.1/30 area 0.0.0.0`	Advertise loopback address in OSPF.
`PE2(config-router)#network 10.1.4.1/30 area 0.0.0.0`	Advertise network address in OSPF.
`PE2(config-router)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval with an interval of `3`, a minimum receive interval of `3`, and a multiplier of `3`.
`PE2(config-router)#exit`	Exit router OSPF mode and return to the configure mode.
`PE2(config)#commit`	Commit the transaction.

PE2: BGP Configuration

The below BGP configuration on PE2 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

`PE2(config)#router bgp 65010`	Enter the Router BGP mode, ASN: 65010
`PE2(config-router)#bgp router-id 10.10.10.2`	Configure BGP router ID `10.10.10.2`, identifying PE2 within the BGP network.

`PE2(config-router)#neighbor 10.10.10.1 remote-as 65010`	Configure neighbor `10.10.10.1` as an iBGP neighbor with their remote AS number `65010`.
`PE2(config-router)#neighbor 10.10.10.1 update-source lo`	Configure neighbor `10.10.10.1` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE2(config-router)#neighbor 10.10.10.3 remote-as 65010`	Configure neighbor `10.10.10.3` as an iBGP neighbor with their remote AS number `65010`.
`PE2(config-router)#neighbor 10.10.10.3 update-source lo`	Configure neighbor `10.10.10.3` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE2(config-router)#neighbor 10.10.10.4 remote-as 65010`	Configure neighbor `10.10.10.4` as an iBGP neighbor with their remote AS number `65010`.
`PE2(config-router)#neighbor 10.10.10.4 update-source lo`	Configure neighbor `10.10.10.4` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE2(config-router)#neighbor 10.10.10.1 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE2(config-router)#neighbor 10.10.10.3 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE2(config-router)#neighbor 10.10.10.4 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE2(config-router)#neighbor 10.10.10.1 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE2(config-router)#neighbor 10.10.10.3 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE2(config-router)#neighbor 10.10.10.4 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE2(config-router)#address-family l2vpn evpn`	Enter into address family mode for L2VPN EVPN.
`PE2(config-router-af)#neighbor 10.10.10.1 activate`	Activate EVPN for iBGP neighbor `10.10.10.1` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE2(config-router-af)#neighbor 10.10.10.3 activate`	Activate EVPN for iBGP neighbor `10.10.10.3` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE2(config-router-af)#neighbor 10.10.10.4 activate`	Activate EVPN for iBGP neighbor `10.10.10.4` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE2(config-router-af)#exit`	Exit address family mode and return to the router BGP mode.
`PE2(config-router)#commit`	Commit the transaction.
`PE2(config-router)#exit`	Exit router BGP mode and return to the configure mode.

PE2: MAC VRF Configuration

The below MAC VRF configuration on PE2 is carried out to define and set up VRFs named `vrf2` and `vpls1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

`PE2(config)#mac vrf vrf2`	Enter VRF mode named `vrf2`.
`PE2(config-vrf)#rd 10.10.10.2:1700`	Configure Route-Distinguisher value of `10.10.10.2:1700`.
`PE2(config-vrf)#route-target both 1700:1700`	Configure import and export values for the `vrf2` as `1700:1700`.
`PE2(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE2(config)#mac vrf vpls1001`	Enter VRF mode named `vpls1001`.
`PE2(config-vrf)#rd 10.10.10.2:1001`	Configure Route-Distinguisher value of `10.10.10.2:1001`.
`PE2(config-vrf)#route-target both 1001:1001`	Configure import and export values for the `vpls1001` as `1001:1001`.
`PE2(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE2(config)#commit`	Commit the transaction.

PE2: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE2 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

`PE2(config)#evpn mpls id 1800 xconnect target-mpls-id 1700`	Configure the EVPN-VPWS identifier with a source identifier of `1800` and a target identifier of `1700`.
`PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Map VRF `vrf2` to the EVPN-VPWS identifier
`PE2(config-evpn-mpls)#commit`	Commit the transaction.
`PE2(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.
`PE2(config)#evpn mpls id 3000`	Configure the EVPN-VPLS identifier an identifier of `3000`.
`PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001`	Map VRF `vpls1001` to the EVPN-VPWS identifier
`PE2(config-evpn-mpls)#commit`	Commit the transaction.
`PE2(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE2 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

`PE2(config)#interface po1`	Enter the port channel interface mode for `po1`
`PE2(config-if)#load-interval 30`	Set the load interval to `30`.
`PE2(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active`	Configure the system-mac address `0000.1111.7777` for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE2(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE2(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE2(config-if)#exit`	Exit interface mode `po1` and return to the configure mode.

PE2(config)#commit	Commit the transaction.
PE2(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE2(config)#interface xe08	Enter the interface mode for xe8.
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE2(config-if)#exit	Exit interface mode xe8 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE2 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE2(config)#interface sa2	Enter the single active interface mode for sa2.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active	Configure the ESI with the value 00:00:11:11:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE2(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE2(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE2(config-if)#exit	Exit interface mode sa2 and return to the configure mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface sa2.1 switchport	Create a Layer 2 sub-interface sa2.1 within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode sa2.1 and return to the configure mode.
PE2(config)#interface xe8	Enter the interface mode for xe8.
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#static-channel-group 2	Attach the static-channel-group 2, the LAG interface sa2 to xe8.

PE2(config-if)#exit	Exit interface mode xe8 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

P1: Loopback Interface

The configuration on P1 for a loopback interface with IP address 10.10.10.5/32 secondary is set up to provide IP connectivity for the router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter the interface mode for the loopback interface lo.
P1(config-if)#ip address 10.10.10.5/32 secondary	Configure a secondary IP address, 10.10.10.5/32, on the loopback interface.
P1(config-if)#exit	Exit interface mode lo.
P1(config)#commit	Commit the transaction.

P1: Global LDP

The configuration on P1 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

P1(config)#router ldp	Enter the Router LDP mode.
P1(config-router)#router-id 10.10.10.5	Set the router ID for LDP to 10.10.10.5.
P1(config-router)#transport-address ipv4 10.10.10.5	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
P1(config-router)#exit	Exit router LDP mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P1: Interface Configuration

The below configuration is performed to set up interfaces on P1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P1(config)#interface xe1	Enter interface mode xe1.
P1(config-if)#ip address 10.1.1.2/30	Configure an IP address, 10.1.1.2/30, on the interface xe1.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe1.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe2	Enter interface mode xe2.
P1(config-if)#ip address 10.1.4.2/30	Configure an IP address, 10.1.4.2/30, on the interface xe2.

P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe2.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe3	Enter interface mode xe3.
P1(config-if)#ip address 10.1.5.2/30	Configure an IP address, 10.1.5.2/30, on the interface xe3.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe3.
P1(config)#commit	Commit the transaction.
P1(config)#interface xe4	Enter interface mode xe4.
P1(config-if)#ip address 10.1.6.2/30	Configure an IP address, 10.1.6.2/30, on the interface xe4.
P1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P1(config-if)#exit	Exit interface mode xe4.
P1(config)#commit	Commit the transaction.

P1: OSPF Configuration

The below configuration is performed to set up OSPF on P1, specifying the router ID, and defining network interfaces for efficient routing.

P1(config)#router ospf 100	Enter the router OSPF mode. Configure P1 to run OSPF with process ID 100.
P1(config-router)#ospf router-id 10.10.10.5	Set the OSPF router ID to 10.10.10.5, identifying P1 within the OSPF network.
P1(config-router)#network 10.10.10.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
P1(config-router)#network 10.1.1.2/30 area 0.0.0.0	Advertise network address in OSPF.
P1(config-router)#network 10.1.4.2/30 area 0.0.0.0	Advertise network address in OSPF.
P1(config-router)#network 10.1.5.2/30 area 0.0.0.0	Advertise network address in OSPF.
P1(config-router)#network 10.1.6.2/30 area 0.0.0.0	Advertise network address in OSPF.

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P1(config-router)#exit	Exit router OSPF mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P2: Loopback Interface

The configuration on P2 for a loopback interface with IP address `10.10.10.6/32` secondary is set up to provide IP connectivity for the router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter the interface mode for the loopback interface `lo`.
P2(config-if)#ip address 10.10.10.6/32 secondary	Configure a secondary IP address, `10.10.10.6/32`, on the loopback interface.
P2(config-if)#exit	Exit interface mode `lo`.
P2(config)#commit	Commit the transaction.

P2: Global LDP

The configuration on P2 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

P2(config)#router ldp	Enter the Router LDP mode.
P2(config-router)#router-id 10.10.10.6	Set the router ID for LDP to `10.10.10.6`.
P2(config-router)#transport-address ipv4 10.10.10.6	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
P2(config-router)#exit	Exit router LDP mode and return to the configure mode.
P2(config)#commit	Commit the transaction.

P2: Interface Configuration

The below configuration is performed to set up interfaces on P2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P2(config)#interface xe12	Enter interface mode `xe12`.
P2(config-if)#ip address 10.1.2.2/30	Configure an IP address, `10.1.2.2/30`, on the interface `xe12`.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode `xe12`.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe13	Enter interface mode `xe13`.
P2(config-if)#ip address 10.1.3.2/30	Configure an IP address, `10.1.3.2/30`, on the interface `xe13`.

P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode xe13.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe11	Enter interface mode xe11.
P2(config-if)#ip address 10.1.7.2/30	Configure an IP address, 10.1.7.2/30, on the interface xe11.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode xe11.
P2(config)#commit	Commit the transaction.
P2(config)#interface xe14	Enter interface mode xe14.
P2(config-if)#ip address 10.1.8.2/30	Configure an IP address, 10.1.8.2/30, on the interface xe14.
P2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
P2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
P2(config-if)#exit	Exit interface mode xe14.
P2(config)#commit	Commit the transaction.

P2: OSPF Configuration

The below configuration is performed to set up OSPF on P2, specifying the router ID, and defining network interfaces for efficient routing.

P2(config)#router ospf 100	Enter the router OSPF mode. Configure P2 to run OSPF with process ID 100.
P2(config-router)#ospf router-id 10.10.10.6	Set the OSPF router ID to 10.10.10.6, identifying P2 within the OSPF network.
P2(config-router)#network 10.10.10.6/32 area 0.0.0.0	Advertise loopback address in OSPF.
P2(config-router)#network 10.1.2.2/30 area 0.0.0.0	Advertise network address in OSPF.
P2(config-router)#network 10.1.3.2/30 area 0.0.0.0	Advertise network address in OSPF.
P2(config-router)#network 10.1.7.2/30 area 0.0.0.0	Advertise network address in OSPF.
P2(config-router)#network 10.1.8.2/30 area 0.0.0.0	Advertise network address in OSPF.

P2(config-router)#exit	Exit router OSPF mode and return to the configure mode.
P2(config)#commit	Commit the transaction.

PE3: Loopback Interface

The configuration on PE3 for a loopback interface with IP address `10.10.10.3/32` secondary is set up to provide IP connectivity for the router.

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter the interface mode for the loopback interface `lo`.
PE3(config-if)#ip address 10.10.10.3/32 secondary	Configure a secondary IP address, `10.10.10.3/32`, on the loopback interface.
PE3(config-if)#exit	Exit interface mode `lo`.
PE3(config)#commit	Commit the transaction.

PE3: Global LDP

The configuration on PE3 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE3(config)#router ldp	Enter the Router LDP mode.
PE3(config-router)#router-id 10.10.10.3	Set the router ID for LDP to `10.10.10.3`.
PE2(config-router)#transport-address ipv4 10.10.10.3	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE3(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: Global EVPN MPLS Command

The configuration on PE3 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE3(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE3, enabling it to participate in EVPN MPLS services.
PE3(config)#commit	Commit candidate configuration to be running configuration.
PE3(config)#evpn mpls vtep-ip-global 10.10.10.3	Configure the global VTEP IP address 10.10.10.3, associating it with the loopback IP.
PE3(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE3(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE3 to support multi-homed EVPN MPLS services.
PE3(config)#commit	Commit the transaction.

PE3: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE3 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE3(config)#interface xe1	Enter interface mode xe1.
PE3(config-if)#ip address 10.1.6.1/30	Configure an IP address, 10.1.6.1/30, on the interface xe1.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#exit	Exit interface mode xe1.
PE3(config)#commit	Commit the transaction.
PE3(config)#interface xe5	Enter interface mode xe5.
PE3(config-if)#ip address 10.1.7.1/30	Configure an IP address, 10.1.7.1/30, on the interface xe5.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#exit	Exit interface mode xe5.
PE3(config)#commit	Commit the transaction.

PE3: OSPF Configuration

The below configuration is performed to set up OSPF on PE3, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

PE3(config)#router ospf 100	Enter the router OSPF mode. Configure PE3 to run OSPF with process ID 100.
PE3(config-router)#ospf router-id 10.10.10.3	Set the OSPF router ID to 10.10.10.3, identifying PE3 within the OSPF network.
PE3(config-router)#network 10.10.10.3/32 area 0.0.0.0	Advertise loopback address in OSPF.

PE3(config-router)#network 10.1.6.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE3(config-router)#network 10.1.7.1/30 area 0.0.0.0	Advertise network address in OSPF.
PE3(config-router)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval with an interval of 3, a minimum receive interval of 3, and a multiplier of 3.
PE3(config-router)#exit	Exit router OSPF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: BGP Configuration

The below BGP configuration on PE3 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE3(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE3(config-router)#bgp router-id 10.10.10.3	Configure BGP router ID 10.10.10.2, identifying PE3 within the BGP network.
PE3(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.4 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE3(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.

PE3(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE3(config-router)#commit	Commit the transaction.
PE3(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE3: MAC VRF Configuration

The below MAC VRF configuration on PE3 is carried out to define and set up VRFs named vrf2 and vpls1001 with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE3(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE3(config-vrf)#rd 10.10.10.3:1700	Configure Route-Distinguisher value of 10.10.10.3:1700.
PE3(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE3(config-vrf)#rd 10.10.10.3:1001	Configure Route-Distinguisher value of 10.10.10.3:1001.
PE3(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE3 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE3(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with a source identifier of 1700 and a target identifier of 1800.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE3(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE3 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

`PE3(config)#interface po1`	Enter the port channel interface mode for `po1`
`PE3(config-if)#load-interval 30`	Set the load interval to `30`.
`PE3(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active`	Configure the system-mac address `0000.2222.7777` for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE3(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE3(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE3(config-if)#exit`	Exit interface mode `po1` and return to the configure mode.
`PE3(config)#commit`	Commit the transaction.
`PE3(config)#interface po1.1 switchport`	Create a Layer 2 sub-interface `po1.1` within the port channel.
`PE3(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE3(config-if)#load-interval 30`	Set the load interval to `30`.
`PE3(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE3(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE3(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE3(config-if)#exit`	Exit interface mode `po1.1` and return to the configure mode.
`PE3(config)#interface xe2`	Enter the interface mode for `xe2`.
`PE3(config-if)#speed 10g`	Set the speed to `10g`.
`PE3(config-if)#channel-group 1 mode active`	Attach LAG interface `po1`.
`PE3(config-if)#exit`	Exit interface mode `xe2` and return to the configure mode.
`PE3(config)#commit`	Commit the transaction.

PE3: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE3 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

`PE3(config)#interface sa1`	Enter the single active interface mode for `sa1`.
`PE3(config-if)#load-interval 30`	Set the load interval to `30`.
`PE3(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active`	Configure the ESI with the value with the value `00:00:22:22:77:77` for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE3(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE3(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE3(config-if)#exit`	Exit interface mode `sa1` and return to the configure mode.

PE3(config)#commit	Commit the transaction.
PE3(config)#interface sa1.1 switchport	Create a Layer 2 sub-interface sa1.1 within the port channel.
PE3(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE3(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE3(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE3(config-if)#exit	Exit interface mode sa1.1 and return to the configure mode.
PE3(config)#interface xe2	Enter the interface mode for xe2.
PE3(config-if)#speed 10g	Set the speed to 10g.
PE3(config-if)#static-channel-group 1	Attach the static-channel-group 1, the LAG interface sa1 to xe2.
PE3(config-if)#exit	Exit interface mode xe2 and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE4: Loopback Interface

The configuration on PE4 for a loopback interface with IP address 10.10.10.4/32 secondary is set up to provide IP connectivity for the router.

PE4#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE4(config-if)#ip address 10.10.10.4/32 secondary	Configure a secondary IP address, 10.10.10.4/32, on the loopback interface.
PE4(config-if)#exit	Exit interface mode lo.
PE4(config)#commit	Commit the transaction.

PE4: Global LDP

The configuration on PE4 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE4(config)#router ldp	Enter the Router LDP mode.
PE4(config-router)#router-id 10.10.10.4	Set the router ID for LDP to 10.10.10.4.
PE4(config-router)#transport-address ipv4 10.10.10.4	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE4(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.

PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: Global EVPN MPLS Command

The configuration on PE4 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE4(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE4, enabling it to participate in EVPN MPLS services.
PE4(config)#commit	Commit candidate configuration to be running configuration.
PE4(config)#evpn mpls vtep-ip-global 10.10.10.4	Configure the global VTEP IP address 10.10.10.4, associating it with the loopback IP.
PE4(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE4(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE4 to support multi-homed EVPN MPLS services.
PE4(config)#commit	Commit the transaction.

PE4: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE4 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE4(config)#interface xe2	Enter interface mode xe2.
PE4(config-if)#ip address 10.1.5.1/30	Configure an IP address, 10.1.5.1/30, on the interface xe2.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE4(config-if)#exit	Exit interface mode xe2.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface xe0	Enter interface mode xe0.
PE4(config-if)#ip address 10.1.8.1/30	Configure an IP address, 10.1.8.1/30, on the interface xe0.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

PE4(config-if)#exit	Exit interface mode xe0.
PE4(config)#commit	Commit the transaction.

PE4: OSPF Configuration

The below configuration is performed to set up OSPF on PE4, specifying the router ID, defining network interfaces, and configuring BFD parameters for efficient routing.

PE4(config)#router ospf 100	Enter the router OSPF mode. Configure PE4 to run OSPF with process ID 100.
PE4(config-router)#ospf router-id 10.10.10.4	Set the OSPF router ID to 10.10.10.4, identifying PE3 within the OSPF network.
PE4(config-router)#network 10.10.10.4/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE4(config-router)#network 10.1.5.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE4(config-router)#network 10.1.8.1/30 area 0.0.0.0	Advertise network address in OSPF.
PE4(config-router)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval with an interval of 3, a minimum receive interval of 3, and a multiplier of 3.
PE4(config-router)#exit	Exit router OSPF mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: BGP Configuration

The below BGP configuration on PE4 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE4(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE4(config-router)#bgp router-id 10.10.10.4	Configure BGP router ID 10.10.10.4, identifying PE4 within the BGP network.
PE4(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.

`PE4(config-router)#neighbor 10.10.10.2 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE4(config-router)#neighbor 10.10.10.3 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE4(config-router)#neighbor 10.10.10.1 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE4(config-router)#neighbor 10.10.10.2 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE4(config-router)#neighbor 10.10.10.3 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE4(config-router)#address-family l2vpn evpn`	Enter into address family mode for L2VPN EVPN.
`PE4(config-router-af)#neighbor 10.10.10.1 activate`	Activate EVPN for iBGP neighbor `10.10.10.1` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE4(config-router-af)#neighbor 10.10.10.2 activate`	Activate EVPN for iBGP neighbor `10.10.10.2` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE4(config-router-af)#neighbor 10.10.10.3 activate`	Activate EVPN for iBGP neighbor `10.10.10.3` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE4(config-router-af)#exit`	Exit address family mode and return to the router BGP mode.
`PE4(config-router)#commit`	Commit the transaction.
`PE4(config-router)#exit`	Exit router BGP mode and return to the configure mode.

PE4: MAC VRF Configuration

The below MAC VRF configuration on PE4 is carried out to define and set up VRFs named `vrf2` and `vpls1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

`PE4(config)#mac vrf vrf2`	Enter VRF mode named `vrf2`.
`PE4(config-vrf)#rd 10.10.10.4:1700`	Configure Route-Distinguisher value of `10.10.10.4:1700.`
`PE4(config-vrf)#route-target both 1700:1700`	Configure import and export values for the `vrf2` as `1700:1700.`
`PE4(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE4(config)#mac vrf vpls1001`	Enter VRF mode named `vpls1001`.
`PE4(config-vrf)#rd 10.10.10.4:1001`	Configure Route-Distinguisher value of `10.10.10.4:1001.`
`PE4(config-vrf)#route-target both 1001:1001`	Configure import and export values for the `vpls1001` as `1001:1001.`
`PE4(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE4(config)#commit`	Commit the transaction.

PE4: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE4 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

`PE4(config)#evpn mpls id 1700 xconnect target-mpls-id 1800`	Configure the EVPN-VPWS identifier with a source identifier of `1700` and a target identifier of `1800`.
`PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Map VRF `vrf2` to the EVPN-VPWS identifier
`PE4(config-evpn-mpls)#commit`	Commit the transaction.
`PE4(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.
`PE4(config)#evpn mpls id 3000`	Configure the EVPN-VPLS identifier an identifier of `3000`.
`PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001`	Map VRF `vpls1001` to the EVPN-VPWS identifier
`PE4(config-evpn-mpls)#commit`	Commit the transaction.
`PE4(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

PE4: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE4 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

`PE4(config)#interface po1`	Enter the port channel interface mode for `po1`
`PE4(config-if)#load-interval 30`	Set the load interval to `30`.
`PE4(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active`	Configure the system-mac address `0000.2222.7777` for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE4(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE4(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE4(config-if)#exit`	Exit interface mode `po1` and return to the configure mode.
`PE4(config)#commit`	Commit the transaction.
`PE4(config)#interface po1.1 switchport`	Create a Layer 2 sub-interface `po1.1` within the port channel.
`PE4(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE4(config-if)#load-interval 30`	Set the load interval to `30`.
`PE4(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE4(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE4(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE4(config-if)#exit`	Exit interface mode `po1.1` and return to the configure mode.
`PE4(config)#interface xe11`	Enter the interface mode for `xe11.`
`PE4(config-if)#speed 10g`	Set the speed to `10g`.
`PE4(config-if)#channel-group 1 mode active`	Attach LAG interface `po1.`
`PE4(config-if)#exit`	Exit interface mode `xe11` and return to the configure mode.
`PE4(config)#commit`	Commit the transaction.

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PE4: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE4 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

`PE4(config)#interface sa2`	Enter the single active interface mode for `sa2`.
`PE4(config-if)#load-interval 30`	Set the load interval to `30`.
`PE4(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active`	Configure the ESI with the value with the value `00:00:22:22:77:77` for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE4(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE4(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE4(config-if)#exit`	Exit interface mode `sa2` and return to the configure mode.
`PE4(config)#commit`	Commit the transaction.
`PE4(config)#interface sa2.1 switchport`	Create a Layer 2 sub-interface `sa2.1` within the port channel.
`PE4(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE4(config-if)#load-interval 30`	Set the load interval to `30`.
`PE4(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE4(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE4(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE4(config-if)#exit`	Exit interface mode `sa2.1` and return to the configure mode.
`PE4(config)#interface xe11`	Enter the interface mode for `xe11`.
`PE4(config-if)#speed 10g`	Set the speed to `10g`.
`PE4(config-if)#static-channel-group 2`	Attach the static-channel-group 2, the LAG interface `sa2` to `xe11`.
`PE4(config-if)#exit`	Exit interface mode `xe11` and return to the configure mode.
`PE4(config)#commit`	Commit the transaction.

CE2

The following configuration steps under CE2 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

`CE2#configure terminal`	Enter configure mode.
`CE2(config)#bridge 1 protocol ieee vlan-bridge`	Set up `bridge 1` to use the IEEE VLAN bridge protocol.
`CE2(config)#vlan 2-100 bridge 1 state enable`	Configure VLANs from `2-100` and associate them with bridge 1.
`CE2(config)#interface xe24`	Enter interface mode `xe24`.
`CE2(config-if)#switchport`	Configure the interface `xe24` as a Layer 2 switch port.
`CE2(config-if)#bridge-group 1`	Associate `xe24` to bridge 1.
`CE2(config-if)#switchport mode trunk`	Configure `xe24` as a trunk port.

CE2(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk interface xe24.
CE2(config-if)#exit	Exit interface mode xe24.
CE2(config)#interface po1	Enter interface mode and configure LAG interface port-channel 1 (po1).
CE2(config-if)#switchport	Configures port-channel 1 as a Layer 2 switch port.
CE2(config-if)#bridge-group 1	Associate po1 to bridge 1.
CE2(config-if)#switchport mode trunk	Configure po1 as a trunk port.
CE2(config-if)#switchport trunk allowed vlan all	Allow all configured VLANs on the trunk port-channel po1.
CE2(config-if)#exit	Exit interface mode po1.
CE2(config)#interface xe22	Enter interface mode xe22.
CE2(config-if)#lacp timeout short	Configure LACP timeout as short.
CE2(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE2(config-if)#exit	Exit interface mode xe22.
CE2(config-if)#interface xe23	Enter interface mode xe23.
CE2(config-if)#lacp timeout short	Configure LACP timeout as short.
CE2(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE2(config-if)#commit	Commit the transaction.
CE2(config-if)#end	Exit interface mode xe23 and configure mode.

EVPN MPLS Active-Standby MH Validation

The following show outputs provide validation results for both single-active and port-active modes, covering ELINE and ELAN services configurations with LDP as the underlay MPLS path.

Single-Active

The following show output displays the types of load-balancing port selection criteria (PSC) used on configured static aggregators for CE1, PE1, PE2, PE3, PE4, and CE2 devices in the network Figure 3-7 using the **show static-channel-group** command.

```
CE1#show static-channel-group
 Static Aggregator: sa1
 Member Status
  xe48   up
-------------------------------------------
 Static Aggregator: sa2
 Member Status
  xe50   up

PE1#show static-channel-group
 Static Aggregator: sa1
 Member Status  weight
  xe0    up

PE2#show static-channel-group
 Static Aggregator: sa2
 Member Status  weight
  xe8    up

PE3#show static-channel-group
 Static Aggregator: sa1
 Member Status  weight
  xe2    up
```

```
PE4#show static-channel-group
 Static Aggregator: sa2
 Member Status  weight
  xe11   up

CE2#show static-channel-group
 Static Aggregator: sa1
 Member Status  weight
  xe23   up
------------------------------------------
 Static Aggregator: sa2
 Member Status  weight
  ge11   up
```

Single-Active ELINE

The following show output displays the active EVPN MPLS Tunnels and load balance for ELINE on PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show evpn load-balance all** and **show evpn mpls xconnect tunnel** commands.

```
PE1#show evpn load-balance all
ESI                          AC-IF/PE     PE-IP-ADDRESS    Redundancy         Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:11:22:33:00:00:00:55:66:77  sa1.1       10.10.10.1       single-active      auto               0        NO          NO
ACTIVE
00:11:22:33:00:00:00:55:66:77  ----        10.10.10.2       single-active      auto               0        NO          NO
----

PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down       Update        local-evpn-id remote-evpn-id
==========================================================================================================
10.10.10.1       10.10.10.4       Installed      00:14:05      00:03:58      1800          1700
10.10.10.1       10.10.10.3       Installed      00:14:05      00:04:29      1800          1700

Total number of entries are 2

PE2#show evpn load-balance all
ESI                          AC-IF/PE     PE-IP-ADDRESS    Redundancy         Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:11:22:33:00:00:00:55:66:77  ----        10.10.10.1       single-active      auto               0        NO          NO
----
00:11:22:33:00:00:00:55:66:77  sa2.1       10.10.10.2       single-active      auto               0        NO          NO
STANDBY
ELINE
PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down       Update        local-evpn-id remote-evpn-id
==========================================================================================================
10.10.10.2       10.10.10.4       Installed      00:12:33      00:04:08      1800          1700
10.10.10.2       10.10.10.3       Installed      00:12:33      00:04:08      1800          1700

Total number of entries are 2

PE3#show evpn load-balance all
ESI                          AC-IF/PE     PE-IP-ADDRESS    Redundancy         Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:12:22:33:00:00:00:55:66:77  sa1.1       10.10.10.3       single-active      auto               0        NO          NO
ACTIVE
00:12:22:33:00:00:00:55:66:77  ----        10.10.10.4       single-active      auto               0        NO          NO
----

PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down       Update        local-evpn-id remote-evpn-id
==========================================================================================================
10.10.10.3       10.10.10.2       Installed      00:13:15      00:04:12      1700          1800
10.10.10.3       10.10.10.1       Installed      00:13:15      00:04:44      1700          1800
```

```
Total number of entries are 2

PE4#show evpn load-balance all
ESI                           AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:12:22:33:00:00:00:55:66:77  ----        10.10.10.3       single-active      auto              0        NO          NO
----
00:12:22:33:00:00:00:55:66:77  sa2.1       10.10.10.4       single-active      auto              0        NO          NO
STANDBY

PE4#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down       Update        local-evpn-id remote-evpn-id
==================================================================================================
10.10.10.4       10.10.10.2       Installed      00:12:52      00:04:17      1700          1800
10.10.10.4       10.10.10.1       Installed      00:12:52      00:04:17      1700          1800

Total number of entries are 2
```

Single-Active ELAN

The following show output displays the active EVPN SR Tunnels and load balance for ELAN on PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show evpn mpls tunnel** and **show evpn load-balance all** commands.

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down       Update        evpn-id
==================================================================================
10.10.10.1       10.10.10.2       Installed      00:17:00      00:17:00      3000
10.10.10.1       10.10.10.4       Installed      00:18:10      00:18:10      3000
10.10.10.1       10.10.10.3       Installed      00:18:10      00:18:10      3000

Total number of entries are 3

PE1#show evpn load-balance all
ESI                           AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:11:22:33:00:00:00:55:66:77  sa1.1       10.10.10.1       single-active      auto              0        NO          NO
ACTIVE
00:11:22:33:00:00:00:55:66:77  ----        10.10.10.2       single-active      auto              0        NO          NO
----



PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down       Update        evpn-id
==================================================================================
10.10.10.2       10.10.10.4       Installed      00:17:09      00:17:09      3000
10.10.10.2       10.10.10.3       Installed      00:17:09      00:17:09      3000
10.10.10.2       10.10.10.1       Installed      00:17:09      00:17:09      3000

Total number of entries are 3

PE2#show evpn load-balance all
ESI                           AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:11:22:33:00:00:00:55:66:77  ----        10.10.10.1       single-active      auto              0        NO          NO
----
00:11:22:33:00:00:00:55:66:77  sa2.1       10.10.10.2       single-active      auto              0        NO          NO
STANDBY

PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down       Update        evpn-id
==================================================================================
10.10.10.3       10.10.10.2       Installed      00:17:11      00:17:11      3000
10.10.10.3       10.10.10.1       Installed      00:18:21      00:18:21      3000
```

```
10.10.10.3       10.10.10.4       Installed     00:29:15      00:28:54      3000

Total number of entries are 3

PE3#show evpn load-balance all
ESI                           AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight    Revertive  AC-DF
Status
=======================================================================================================================
=========
00:12:22:33:00:00:00:55:66:77  sa1.1        10.10.10.3       single-active      auto              0        NO           NO
ACTIVE
00:12:22:33:00:00:00:55:66:77  ----         10.10.10.4       single-active      auto              0        NO           NO
----

PE4#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=======================================================================================
10.10.10.4       10.10.10.2       Installed     00:17:13      00:17:13      3000
10.10.10.4       10.10.10.1       Installed     00:18:23      00:18:23      3000
10.10.10.4       10.10.10.3       Installed     00:29:18      00:29:14      3000

Total number of entries are 3

PE4#show evpn load-balance all
ESI                           AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight    Revertive  AC-DF
Status
=======================================================================================================================
=========
00:12:22:33:00:00:00:55:66:77  ----         10.10.10.3       single-active      auto              0        NO           NO
----
00:12:22:33:00:00:00:55:66:77  sa2.1        10.10.10.4       single-active      auto              0        NO           NO
STANDBY
```

Port-Active

The following show output displays the Ether Channel summary for CE1, CE2, PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show etherchannel summary** command.

```
CE1#show etherchannel summary
  Aggregator po1 100001
  Aggregator Type: Layer2
  Admin Key: 0001 - Oper Key 0001
     Link: xe48 (5049) sync: 0
     Link: xe50 (5051) sync: 1
CE2#show etherchannel summary
  Aggregator po1 100001
  Aggregator Type: Layer2
  Admin Key: 0001 - Oper Key 0001
     Link: ge11 (5011) sync: 1
     Link: xe23 (5023) sync: 0
PE1#show etherchannel summary
  Aggregator po1 100001
  Aggregator Type: Layer3
  Admin Key: 0001 - Oper Key 0001
     Link: xe0 (10004) sync: 0
PE2#show etherchannel summary
  Aggregator po1 100001
  Aggregator Type: Layer3
  Admin Key: 0001 - Oper Key 0001
     Link: xe8 (10029) sync: 1
PE3#show etherchannel summary
  Aggregator po1 100001
```

```
  Aggregator Type: Layer3
  Admin Key: 0001 - Oper Key 0001
     Link: xe2 (10003) sync: 0
PE4#show etherchannel summary
  Aggregator po1 100001
  Aggregator Type: Layer3
  Admin Key: 0001 - Oper Key 0001
     Link: xe11 (10012) sync: 1
```

The following show output displays the status of LDP sessions on PE1, PE2, PE3, PE4, P1, and P2 devices in the network Figure 3-7 using the **show ldp session** command.

```
PE1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       10.10.10.2          xe2        Passive   OPERATIONAL   30     00:06:57
       10.10.10.3          xe14       Passive   OPERATIONAL   30     00:07:12
       10.10.10.4          xe14       Passive   OPERATIONAL   30     00:06:42
       10.10.10.5          xe14       Passive   OPERATIONAL   30     00:07:26
       10.10.10.6          xe2        Passive   OPERATIONAL   30     00:06:36

PE2#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       10.10.10.1          xe4        Active    OPERATIONAL   30     00:07:05
       10.10.10.3          xe4        Passive   OPERATIONAL   30     00:07:05
       10.10.10.4          xe4        Passive   OPERATIONAL   30     00:07:05
       10.10.10.5          xe5        Passive   OPERATIONAL   30     00:07:03
       10.10.10.6          xe4        Passive   OPERATIONAL   30     00:07:13

P1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       10.10.10.1          xe1        Active    OPERATIONAL   30     00:07:41
       10.10.10.2          xe2      Active    OPERATIONAL   30     00:07:11
       10.10.10.3          xe4        Active    OPERATIONAL   30     00:07:13
       10.10.10.4          xe3      Active    OPERATIONAL   30     00:07:10

P2#show ldp session
Codes: m - MD5 password is not set/unset.
```

```
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       10.10.10.1         xe12       Active    OPERATIONAL   30    00:06:55
       10.10.10.2         xe13       Active    OPERATIONAL   30    00:07:24
       10.10.10.3         xe11        Active    OPERATIONAL   30    00:01:47
       10.10.10.4         xe14       Active    OPERATIONAL   30    00:06:56

PE3#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       10.10.10.1         xe5        Active    OPERATIONAL   30    00:07:35
       10.10.10.2         xe5        Active    OPERATIONAL   30    00:07:20
       10.10.10.4         xe5        Passive   OPERATIONAL   30    00:07:07
       10.10.10.5         xe1        Passive   OPERATIONAL   30    00:07:21
       10.10.10.6         xe5        Passive   OPERATIONAL   30    00:01:50

PE4#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       10.10.10.1         xe0        Active    OPERATIONAL   30    00:07:09
       10.10.10.2         xe2        Active    OPERATIONAL   30    00:07:24
       10.10.10.3         xe0        Active    OPERATIONAL   30    00:07:11
       10.10.10.5         xe2        Passive   OPERATIONAL   30    00:07:22
       10.10.10.6         xe0        Passive   OPERATIONAL   30    00:07:03
```

The below show output displays the details about BGP L2VPN EVPN multihoming ES routes and Ethernet advertisement per ES for PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show bgp l2vpn evpn multihoming es-route** command.

```
PE1#show bgp l2vpn evpn multihoming es-route

RD[10.10.10.1:64512] VRF[evpn-gvrf-1]:
ESI                           PE IP-Address   Encap     Peer IP          Algo      AC-DF   DP    weight
00:00:00:11:11:77:77:00:00:00  10.10.10.1      MPLS      ----------       DFT        no     no    0
00:00:00:11:11:77:77:00:00:00  10.10.10.2      MPLS      10.10.10.2       DFT        no     no    0

RD[10.10.10.2:64512]
ESI                           PE IP-Address   Encap     Peer IP          Algo
   AC-DF DP    weight
00:00:00:11:11:77:77:00:00:00  10.10.10.2      MPLS      10.10.10.2       DFT
   no    no    0

PE2#show bgp l2vpn evpn multihoming es-route

RD[10.10.10.1:64512]
ESI                           PE IP-Address   Encap     Peer IP          Algo      AC-DF DP    weight
```

```
00:00:00:11:11:77:77:00:00:00  10.10.10.1      MPLS      10.10.10.1      DFT       no    no    0

RD[10.10.10.2:64512] VRF[evpn-gvrf-1]:
ESI                            PE IP-Address   Encap     Peer IP         Algo      AC-DF DP    weight
00:00:00:11:11:77:77:00:00:00  10.10.10.1      MPLS      10.10.10.1      DFT       no    no    0
00:00:00:11:11:77:77:00:00:00  10.10.10.2      MPLS      ----------      DFT       no    no    0

PE3#show bgp l2vpn evpn multihoming es-route

RD[10.10.10.3:64512] VRF[evpn-gvrf-1]:
ESI                            PE IP-Address   Encap     Peer IP         Algo
   AC-DF DP    weight
00:00:00:22:22:77:77:00:00:00  10.10.10.3      MPLS      ----------      DFT
   no    no    0
00:00:00:22:22:77:77:00:00:00  10.10.10.4      MPLS      10.10.10.4      DFT
   no    no    0

RD[10.10.10.4:64512]
ESI                            PE IP-Address   Encap     Peer IP         Algo
   AC-DF DP    weight
00:00:00:22:22:77:77:00:00:00  10.10.10.4      MPLS      10.10.10.4      DFT
   no    no    0

PE4#show bgp l2vpn evpn multihoming es-route

RD[10.10.10.3:64512]
ESI                            PE IP-Address   Encap     Peer IP         Algo      AC-DF DP    weight
00:00:00:22:22:77:77:00:00:00  10.10.10.3      MPLS      10.10.10.3      DFT       no    no    0

RD[10.10.10.4:64512] VRF[evpn-gvrf-1]:
ESI                            PE IP-Address   Encap     Peer IP         Algo      AC-DF DP    weight
00:00:00:22:22:77:77:00:00:00  10.10.10.3      MPLS      10.10.10.3      DFT       no    no    0
00:00:00:22:22:77:77:00:00:00  10.10.10.4      MPLS      ----------      DFT       no    no    0
```

The following show output displays the details about Layer 2 Virtual Private Network (L2VPN) Ethernet Virtual Private Network (EVPN) routes on PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show bgp l2vpn evpn multihoming ethernet-ad-per-es** and **show bgp l2vpn evpn multihoming ethernet-ad-per-evi** comands.

```
PE1#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[10.10.10.1:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336         10.10.10.2      MPLS      P flag
00:00:00:22:22:77:77:00:00:00  4294967295  440336         10.10.10.3      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  4294967295  440336         10.10.10.4      MPLS      P flag

RD[10.10.10.1:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336         10.10.10.1      MPLS      B flag

RD[10.10.10.2:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336         10.10.10.2      MPLS      P flag

RD[10.10.10.3:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  4294967295  440336         10.10.10.3      MPLS      B flag

RD[10.10.10.4:64512]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  4294967295  440336         10.10.10.4      MPLS      P flag

PE1#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[10.10.10.1:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27522          10.10.10.1      MPLS      B flag
00:00:00:11:11:77:77:00:00:00  1800        27520          10.10.10.2      MPLS      P flag
00:00:00:22:22:77:77:00:00:00  1700        27520          10.10.10.3      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  1700        27520          10.10.10.4      MPLS      P flag

RD[10.10.10.2:1700]
ESI                            Eth-Tag     VNID/LABEL     Nexthop IP      Encap     Flags
```

```
00:00:00:11:11:77:77:00:00:00  1800        27520         10.10.10.2      MPLS      P flag

RD[10.10.10.3:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.3      MPLS      B flag

RD[10.10.10.4:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.4      MPLS      P flag

PE2#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[10.10.10.1:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.1      MPLS      B flag

RD[10.10.10.2:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.1      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.3      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.4      MPLS      P flag

RD[10.10.10.2:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.2      MPLS      P flag

RD[10.10.10.3:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.3      MPLS      B flag

RD[10.10.10.4:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.4      MPLS      P flag

PE2#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[10.10.10.1:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27522         10.10.10.1      MPLS      B flag

RD[10.10.10.2:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27522         10.10.10.1      MPLS      B flag
00:00:00:11:11:77:77:00:00:00  1800        27520         10.10.10.2      MPLS      P flag
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.3      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.4      MPLS      P flag

RD[10.10.10.3:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.3      MPLS      B flag

RD[10.10.10.4:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.4      MPLS      P flag

PE3#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[10.10.10.1:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.1      MPLS      B flag

RD[10.10.10.2:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.2      MPLS      P flag

RD[10.10.10.3:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.2      MPLS      P flag
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.1      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.4      MPLS      P flag

RD[10.10.10.3:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
```

```
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.3      MPLS      B flag

RD[10.10.10.4:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.4      MPLS      P flag

PE3#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[10.10.10.1:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27522         10.10.10.1      MPLS      B flag

RD[10.10.10.2:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27520         10.10.10.2      MPLS      P flag

RD[10.10.10.3:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27520         10.10.10.2      MPLS      P flag
00:00:00:11:11:77:77:00:00:00  1800        27522         10.10.10.1      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.3      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.4      MPLS      P flag

RD[10.10.10.4:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.4      MPLS      P flag

PE4#show bgp l2vpn evpn multihoming ethernet-ad-per-es

RD[10.10.10.1:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.1      MPLS      B flag

RD[10.10.10.2:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.2      MPLS      P flag

RD[10.10.10.3:64512]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.3      MPLS      B flag

RD[10.10.10.4:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.1      MPLS      B flag
00:00:00:11:11:77:77:00:00:00  4294967295  440336        10.10.10.2      MPLS      P flag
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.3      MPLS      B flag

RD[10.10.10.4:64512] VRF[evpn-gvrf-1]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  4294967295  440336        10.10.10.4      MPLS      P flag

PE4#show bgp l2vpn evpn multihoming ethernet-ad-per-evi

RD[10.10.10.1:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27522         10.10.10.1      MPLS      B flag

RD[10.10.10.2:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27520         10.10.10.2      MPLS      P flag

RD[10.10.10.3:1700]
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.3      MPLS      B flag

RD[10.10.10.4:1700] VRF[vrf2]:
ESI                            Eth-Tag     VNID/LABEL    Nexthop IP      Encap     Flags
00:00:00:11:11:77:77:00:00:00  1800        27522         10.10.10.1      MPLS      B flag
00:00:00:11:11:77:77:00:00:00  1800        27520         10.10.10.2      MPLS      P flag
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.3      MPLS      B flag
00:00:00:22:22:77:77:00:00:00  1700        27520         10.10.10.4      MPLS      P flag
```

Port-Active ELINE

The following show output displays the active EVPN MPLS Tunnels for ELINE on PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show evpn mpls xconnect tunnel** command.

```
PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination     Status       Up/Down      Update       local-evpn-id remote-evpn-id
===================================================================================================
10.10.10.1      10.10.10.3      AC-Down      00:31:41     00:31:41     4             1700
10.10.10.1      10.10.10.4      AC-Down      00:31:41     00:31:41     4             1700
Total number of entries are 2

PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination     Status       Up/Down      Update       local-evpn-id remote-evpn-id
===================================================================================================
10.10.10.2      10.10.10.3      Installed    00:12:21     00:11:40     1800          1700
10.10.10.2      10.10.10.4      Installed    00:17:43     00:17:37     1800          1700
Total number of entries are 2

PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination     Status       Up/Down      Update       local-evpn-id remote-evpn-id
===================================================================================================
10.10.10.3      10.10.10.1      AC-Down      00:12:26     00:12:26     1700          1800
10.10.10.3      10.10.10.2      AC-Down      00:12:26     00:12:26     1700          1800

Total number of entries are 2


PE4#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination     Status       Up/Down      Update       local-evpn-id remote-evpn-id
===================================================================================================
10.10.10.4      10.10.10.1      Installed    00:12:28     00:12:28     1700          1800
10.10.10.4      10.10.10.2      Installed    00:12:28     00:12:28     1700          1800

Total number of entries are 2
```

Port-Active ELAN

The following show outputs provide validation for ELAN configurations.

The following show output displays the active EVPN MPLS Tunnels for ELAN on PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show evpn mpls tunnel** command.

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination     Status       Up/Down      Update       evpn-id
=================================================================================
10.10.10.1      10.10.10.4      Installed    00:02:35     00:02:35     3000

10.10.10.1      10.10.10.3      Installed    00:03:00     00:03:00     3000

10.10.10.1      10.10.10.2      Installed    00:03:26     00:03:26     3000


Total number of entries are 3

PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source          Destination     Status       Up/Down      Update       evpn-id
=================================================================================
10.10.10.2      10.10.10.4      Installed    00:02:45     00:02:45     3000

10.10.10.2      10.10.10.3      Installed    00:03:10     00:03:10     3000

10.10.10.2      10.10.10.1      Installed    00:03:36     00:03:36     3000


Total number of entries are 3
```

```
PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
10.10.10.3       10.10.10.4       Installed     00:02:56      00:02:56      3000

10.10.10.3       10.10.10.2       Installed     00:03:22      00:03:22      3000

10.10.10.3       10.10.10.1       Installed     00:03:22      00:03:22      3000


Total number of entries are 3

PE4#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
10.10.10.4       10.10.10.3       Installed     00:03:00      00:03:00      3000

10.10.10.4       10.10.10.1       Installed     00:03:00      00:03:00      3000

10.10.10.4       10.10.10.2       Installed     00:03:00      00:03:00      3000


Total number of entries are 3
```

The following show output displays the EVPN active multi-homed and load-balanced details on PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show evpn load-balance port-active** and **show evpn multi-homing all** commands.

```
PE1#show evpn load-balance port-active
ESI                            AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
========================================================================================================================
00:00:00:11:11:77:77:00:00:00  LOCAL        10.10.10.1       port-active       auto               0        NO           NA
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE       10.10.10.2       port-active       auto               0        NO           NA
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE       10.10.10.3       port-active       ----               ----     ----       ----
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE       10.10.10.4       port-active       ----               ----     ----       ----
ACTIVE

PE1#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  po1          10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.4
Total number of entries are 4

PE2#show evpn load-balance port-active
ESI                            AC-IF/PE  PE-IP-ADDRESS    Redundancy     Service-carving   weight  Revertive  AC-DF   Status
========================================================================================================================
00:00:00:11:11:77:77:00:00:00  REMOTE   10.10.10.1       port-active       auto              0        NO        NA    STANDBY
00:00:00:11:11:77:77:00:00:00  LOCAL    10.10.10.2       port-active      auto              0        NO        NA    ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE   10.10.10.3      port-active      ---              ----    ----       ----    STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE   10.10.10.4       port-active      ----             ----    ----        ----    ACTIVE

PE2#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.1
00:00:00:11:11:77:77:00:00:00  po1          10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.4
Total number of entries are 4

PE3#show evpn load-balance port-active
ESI                            AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
=========================================================================================================================
```

```
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.1       port-active      ----              ----     ----       ----
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.2       port-active      ----              ----     ----       ----
ACTIVE
00:00:00:22:22:77:77:00:00:00  LOCAL       10.10.10.3       port-active      auto              0        NO           NA
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE      10.10.10.4       port-active      auto              0        NO           NA
ACTIVE

PE3#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.2
00:00:00:22:22:77:77:00:00:00  po1          10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.4
Total number of entries are 4

PE4#show evpn load-balance port-active
ESI                           AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.1       port-active      ----              ----     ----       ----
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.2       port-active      ----              ----     ----       ----
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE      10.10.10.3       port-active      auto              0        NO           NA
STANDBY
00:00:00:22:22:77:77:00:00:00  LOCAL       10.10.10.4       port-active      auto              0        NO           NA
ACTIVE

PE4#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.3
00:00:00:22:22:77:77:00:00:00  po1          10.10.10.4
```

EVPN SR Active-Standby Multi-Homing Configuration

This section illustrates the Multi-Homed setup for the EVPN Segment Routing (SR) Active-Standby configuration, showcasing examples for both ELINE and ELAN services with SR as the underlay MPLS path.

EVPN SR Active-Standby MH Topology

Figure 3-8 consists of customer edge routers CE1 and CE2, along with IPv4 Provider Edge routers PE1, PE2, PE3, and PE4, all interconnected through the core routers P1 and P2 in the IPv4 MPLS provider network.

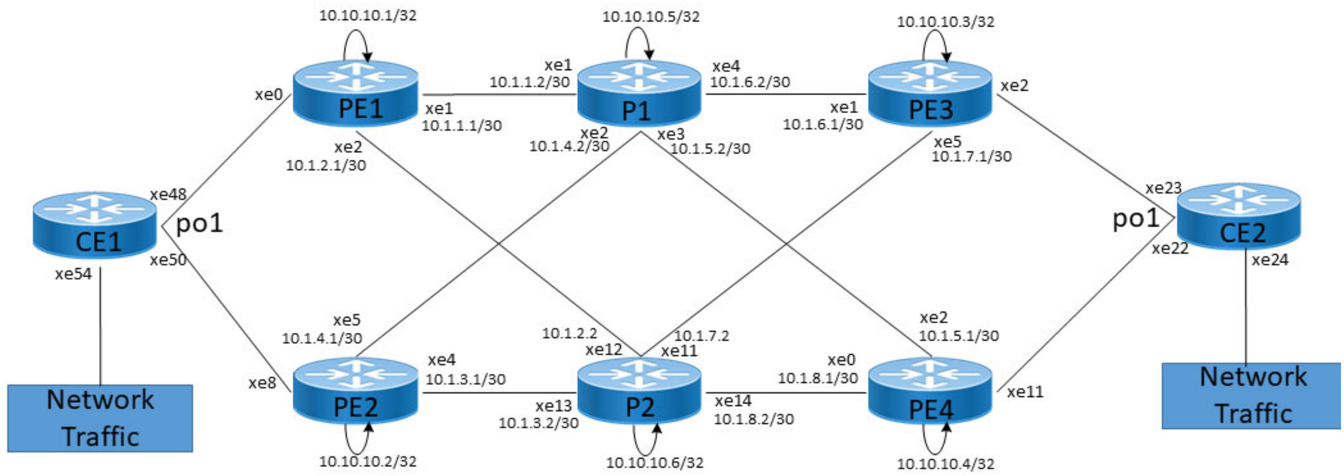

Figure 3-8: EVPN MPLS AS MH Configuration

CE1

The following configuration steps under CE1 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

`CE1#configure terminal`	Enter configure mode.
`CE1(config)#bridge 1 protocol ieee vlan-bridge`	Set up `bridge 1` to use the IEEE VLAN bridge protocol.
`CE1(config)#vlan 2-100 bridge 1 state enable`	Configure VLANs from `2-100` and associate them with bridge 1.
`CE1(config)#interface xe54`	Enter interface mode `xe54`.
`CE1(config-if)#switchport`	Configure the interface `xe54` as a Layer 2 switch port.
`CE1(config-if)#bridge-group 1`	Associate `xe54` to bridge 1.
`CE1(config-if)#switchport mode trunk`	Configure `xe54` as a trunk port.
`CE1(config-if)#switchport trunk allowed vlan all`	Allow all configured VLANs on the trunk interface `xe54`.
`CE1(config-if)#exit`	Exit interface mode `xe54`.
`CE1(config)#interface po1`	Enter interface mode and configure LAG interface port-channel 1 (`po1`).
`CE1(config-if)#switchport`	Configures port-channel 1 as a Layer 2 switch port.
`CE1(config-if)#bridge-group 1`	Associate `po1` to bridge 1.
`CE1(config-if)#switchport mode trunk`	Configure `po1` as a trunk port.
`CE1(config-if)#switchport trunk allowed vlan all`	Allow all configured VLANs on the trunk port-channel `po1`.
`CE1(config-if)#exit`	Exit interface mode `po1`.
`CE1(config)#interface xe48`	Enter interface mode `xe48`.
`CE1(config-if)#lacp timeout short`	Configure LACP timeout as `short`.
`CE1(config-if)#channel-group 1 mode active`	Add member to the LAG interface.
`CE1(config-if)#exit`	Exit interface mode `xe48`.
`CE1(config-if)#interface xe50`	Enter interface mode `xe50`.

CE1(config-if)#lacp timeout short	Configure LACP timeout as short.
CE1(config-if)#channel-group 1 mode active	Add member to the LAG interface.
CE1(config-if)#commit	Commit the transaction.
CE1(config-if)#end	Exit interface mode xe50 and configure mode.

PE1: Loopback Interface

The configuration on PE1 for a loopback interface with IP address 10.10.10.1/32 secondary is set up to provide IP connectivity for the ISIS router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE1(config-if)#ip address 10.10.10.1/32 secondary	Configure a secondary IP address, 10.10.10.1/32, on the loopback interface.
PE1(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
PE1(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
PE1(config-if)#exit	Exit interface mode lo.
PE1(config)#commit	Commit the transaction.

PE1: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE1 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

PE1(config)#segment-routing	Configure segment routing on PE1 device.
PE1(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
PE1(config-sr)#exit	Exit the router SR mode.
PE1(config)#commit	Commit the transaction.

PE1: Global LDP

The configuration on PE1 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE1(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 10.10.10.1	Set the router ID for LDP to 10.10.10.1.
PE1(config-router)#transport-address ipv4 10.10.10.1	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE1(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

The configuration on PE1 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE1(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE1, enabling it to participate in EVPN MPLS services.
PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#evpn mpls vtep-ip-global 10.10.10.1	Configure the global VTEP IP address 10.10.10.1, associating it with the loopback IP.
PE1(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE1(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE1 to support multi-homed EVPN MPLS services.
PE1(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE1(config)#interface xe1	Enter interface mode xe1.
PE1(config-if)#ip address 10.1.1.1/30	Configure an IP address, 10.1.1.1/30, on the interface xe1.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#ip router isis 1	Enable ISIS IPv4 routing on an interface xe1.
PE1(config-if)#exit	Exit interface mode xe1.
PE1(config)#commit	Commit the transaction.
PE1(config)#interface xe2	Enter interface mode xe2.
PE1(config-if)#ip address 10.1.2.1/30	Configure an IP address, 10.1.2.1/30, on the interface xe2.

PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#ip router isis 1	Enable ISIS IPv4 routing on an interface xe2.
PE1(config-if)#exit	Exit interface mode xe2.
PE1(config)#commit	Commit the transaction.

PE1: ISIS Configuration

The below configuration is performed to set up ISIS on PE1, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE1(config)#router isis 1	Enter router ISIS mode.
PE1(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE1(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE1(config-router)#mpls traffic-eng router-id 10.10.10.1	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.1, which is used for MPLS-TE path calculations.
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE1(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE1(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE1(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE1(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE1(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE1(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE1(config-router)#net 49.0000.0000.0001.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE1(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE1(config-router)#segment-routing mpls	Enable SR ISIS.
PE1(config-router)#exit	Exit router ISIS mode and return to configure mode.
PE1(config)#commit	Commit the transaction.

PE1: BGP Configuration

The below BGP configuration on PE1 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

`PE1(config)#router bgp 65010`	Enter the Router BGP mode, ASN: 65010
`PE1(config-router)#bgp router-id 10.10.10.1`	Configure BGP router ID `10.10.10.1`, identifying PE1 within the BGP network.
`PE1(config-router)#neighbor 10.10.10.2 remote-as 65010`	Configure neighbor `10.10.10.2` as an iBGP neighbor with their remote AS number `65010`.
`PE1(config-router)#neighbor 10.10.10.2 update-source lo`	Configure neighbor `10.10.10.2` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#neighbor 10.10.10.3 remote-as 65010`	Configure neighbor `10.10.10.3` as an iBGP neighbor with their remote AS number `65010`.
`PE1(config-router)#neighbor 10.10.10.3 update-source lo`	Configure neighbor `10.10.10.3` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#neighbor 10.10.10.4 remote-as 65010`	Configure neighbor `10.10.10.4` as an iBGP neighbor with their remote AS number `65010`.
`PE1(config-router)#neighbor 10.10.10.4 update-source lo`	Configure neighbor `10.10.10.4` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#neighbor 10.10.10.2 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE1(config-router)#neighbor 10.10.10.3 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE1(config-router)#neighbor 10.10.10.4 fall-over bfd multihop`	Configure BFD for the BGP neighbor to provide rapid failure detection.
`PE1(config-router)#neighbor 10.10.10.2 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE1(config-router)#neighbor 10.10.10.3 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE1(config-router)#neighbor 10.10.10.4 advertisement-interval 0`	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
`PE1(config-router)#address-family l2vpn evpn`	Enter into address family mode for L2VPN EVPN.
`PE1(config-router-af)#neighbor 10.10.10.2 activate`	Activate EVPN for iBGP neighbor `10.10.10.2` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#neighbor 10.10.10.3 activate`	Activate EVPN for iBGP neighbor `10.10.10.3` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#neighbor 10.10.10.4 activate`	Activate EVPN for iBGP neighbor `10.10.10.4` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#exit`	Exit address family mode and return to the router BGP mode.
`PE1(config-router)#commit`	Commit the transaction.
`PE1(config-router)#exit`	Exit router BGP mode and return to the configure mode.

PE1: MAC VRF Configuration

The below MAC VRF configuration on PE1 is carried out to define and set up VRFs named `vrf2` and `vpls1001` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE1(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE1(config-vrf)#rd 10.10.10.1:1700	Configure Route-Distinguisher value of 10.10.10.1:1700.
PE1(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE1(config-vrf)#rd 10.10.10.1:1001	Configure Route-Distinguisher value of 10.10.10.1:1001.
PE1(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE1 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE1(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with a source identifier of 1800 and a target identifier of 1700.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE1(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE1 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE1(config)#interface po1	Enter the port channel interface mode for po1
PE1(config-if)#load-interval 30	Set the load interval to 30.
PE1(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active	Configure the system-mac address 0000.1111.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE1(config-if-es)#service-carving auto	Configure service carving as auto.
PE1(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE1(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

`PE1(config)#interface po1.1 switchport`	Create a Layer 2 sub-interface `po1.1` within the port channel.
`PE1(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE1(config-if)#load-interval 30`	Set the load interval to `30`.
`PE1(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE1(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE1(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE1(config-if)#exit`	Exit interface mode `po1.1` and return to the configure mode.
`PE1(config)#interface xe0`	Enter the interface mode for `xe0.`
`PE1(config-if)#speed 10g`	Set the speed to `10g`.
`PE1(config-if)#channel-group 1 mode active`	Attach LAG interface `po1.`
`PE1(config-if)#exit`	Exit interface mode `xe0` and return to the configure mode.
`PE1(config)#commit`	Commit the transaction.

PE1: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE1 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

`PE1(config)#interface sa1`	Enter the single active interface mode for `sa1`
`PE1(config-if)#load-interval 30`	Set the load interval to `30`.
`PE1(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active`	Configure the ESI with the value with the value `00:00:11:11:77:77` for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE1(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE1(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE1(config-if)#exit`	Exit interface mode `sa1` and return to the configure mode.
`PE1(config)#commit`	Commit the transaction.
`PE1(config)#interface sa1.1 switchport`	Create a Layer 2 sub-interface `sa1.1` within the port channel.
`PE1(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE1(config-if)#load-interval 30`	Set the load interval to `30`.
`PE1(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE1(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE1(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE1(config-if)#exit`	Exit interface mode `sa1.1` and return to the configure mode.
`PE1(config)#interface xe0`	Enter the interface mode for `xe0.`
`PE1(config-if)#speed 10g`	Set the speed to `10g`.
`PE1(config-if)#static-channel-group 1`	Attach the static-channel-group 1, the LAG interface `sa1` to `xe0`.

PE1(config-if)#exit	Exit interface mode xe0 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE2: Loopback Interface

The configuration on PE2 for a loopback interface with IP address 10.10.10.2/32 secondary is set up to provide IP connectivity for the ISIS router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE2(config-if)#ip address 10.10.10.2/32 secondary	Configure a secondary IP address, 10.10.10.2/32, on the loopback interface.
PE2(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
PE2(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
PE2(config-if)#exit	Exit interface mode lo.
PE2(config)#commit	Commit the transaction.

PE2: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE2 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

PE2(config)#segment-routing	Configure segment routing on PE2 device.
PE2(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
PE2(config-sr)#exit	Exit the router SR mode.
PE2(config)#commit	Commit the transaction.

PE2: Global LDP

The configuration on PE2 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE2(config)#router ldp	Enter the Router LDP mode.
PE2(config-router)#router-id 10.10.10.2	Set the router ID for LDP to 10.10.10.2.
PE2(config-router)#transport-address ipv4 10.10.10.2	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE2(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE2(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE2(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE2(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Global EVPN MPLS Command

The configuration on PE2 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE2(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE2, enabling it to participate in EVPN MPLS services.
PE2(config)#commit	Commit candidate configuration to be running configuration.
PE2(config)#evpn mpls vtep-ip-global 10.10.10.2	Configure the global VTEP IP address 10.10.10.2, associating it with the loopback IP.
PE2(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE2(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE2 to support multi-homed EVPN MPLS services.
PE2(config)#commit	Commit the transaction.

PE2: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE2(config)#interface xe4	Enter interface mode xe4.
PE2(config-if)#ip address 10.1.3.1/30	Configure an IP address, 10.1.3.1/30, on the interface xe4.
PE2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe4 for area 1.
PE2(config-if)#exit	Exit interface mode xe4.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface xe5	Enter interface mode xe5.
PE2(config-if)#ip address 10.1.4.1/30	Configure an IP address, 10.1.4.1/30, on the interface xe5.
PE2(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE2(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

PE2(config-if)#ip router isis 1	Enable ISIS routing on an interface xe5 for area 1.
PE2(config-if)#exit	Exit interface mode xe5.
PE2(config)#commit	Commit the transaction.

PE2: ISIS Configuration

The below configuration is performed to set up ISIS on PE2, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE2(config)#router isis 1	Enter router ISIS mode.
PE2(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE2(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE2(config-router)#mpls traffic-eng router-id 10.10.10.2	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.2, which is used for MPLS-TE path calculations.
PE2(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE2(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE2(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE2(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE2(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE2(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE2(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE2(config-router)#net 49.0000.0000.0002.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE2(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE2(config-router)#segment-routing mpls	Enable SR ISIS.
PE2(config-router)#exit	Exit router ISIS mode and return to configure mode.
PE2(config)#commit	Commit the transaction.

PE2: BGP Configuration

The below BGP configuration on PE2 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE2(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE2(config-router)#bgp router-id 10.10.10.2	Configure BGP router ID 10.10.10.2, identifying PE2 within the BGP network.
PE2(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.

PE2(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE2(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE2(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE2(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.3 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.4 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE2(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE2(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE2(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE2(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE2(config-router)#commit	Commit the transaction.
PE2(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE2: MAC VRF Configuration

The below MAC VRF configuration on PE2 is carried out to define and set up VRFs named vrf2 and vpls1001 with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE2(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE2(config-vrf)#rd 10.10.10.2:1700	Configure Route-Distinguisher value of 10.10.10.2:1700.

PE2(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE2(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE2(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE2(config-vrf)#rd 10.10.10.2:1001	Configure Route-Distinguisher value of 10.10.10.2:1001.
PE2(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE2(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE2 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE2(config)#evpn mpls id 1800 xconnect target-mpls-id 1700	Configure the EVPN-VPWS identifier with a source identifier of 1800 and a target identifier of 1700.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE2(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE2 is carried out to configure various parameters including system-mac, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE2(config)#interface po1	Enter the port channel interface mode for po1
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed system-mac 0000.1111.7777 load-balancing port-active	Configure the system-mac address 0000.1111.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE2(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE2(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE2(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface po1.1 switchport	Create a Layer 2 sub-interface po1.1 within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.

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PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE2(config)#interface xe8	Enter the interface mode for xe8.
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE2(config-if)#exit	Exit interface mode xe8 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE2: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE2 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE2(config)#interface sa2	Enter the single active interface mode for sa2.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed esi 00:00:11:11:77:77 load-balancing single-active	Configure the ESI with the value with the value 00:00:11:11:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE2(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE2(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE2(config-if)#exit	Exit interface mode sa2 and return to the configure mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#interface sa2.1 switchport	Create a Layer 2 sub-interface sa2.1 within the port channel.
PE2(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode sa2.1 and return to the configure mode.
PE2(config)#interface xe8	Enter the interface mode for xe8.
PE2(config-if)#speed 10g	Set the speed to 10g.
PE2(config-if)#static-channel-group 2	Attach the static-channel-group 2, the LAG interface sa2 to xe8.
PE2(config-if)#exit	Exit interface mode xe8 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

P1: Loopback Interface

The configuration on P1 for a loopback interface with IP address 10.10.10.5/32 secondary is set up to provide IP connectivity for the router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter the interface mode for the loopback interface lo.
P1(config-if)#ip address 10.10.10.5/32 secondary	Configure a secondary IP address, 10.10.10.5/32, on the loopback interface.
P1(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
P1(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
P1(config-if)#exit	Exit interface mode lo.
P1(config)#commit	Commit the transaction.

P1: Configure SR

The following configurations aim to activate Segment Routing (SR) on P1 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

P1(config)#segment-routing	Configure segment routing on P1 device.
P1(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
P1(config-sr)#exit	Exit the router SR mode.
P1(config)#commit	Commit the transaction.

P1: Global LDP

The configuration on P1 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

P1(config)#router ldp	Enter the Router LDP mode.
P1(config-router)#router-id 10.10.10.5	Set the router ID for LDP to 10.10.10.5.
P1(config-router)#transport-address ipv4 10.10.10.5	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
P1(config-router)#exit	Exit router LDP mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P1: Interface Configuration

The below configuration is performed to set up interfaces on P1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

P1(config)#interface xe1	Enter interface mode xe1.
P1(config-if)#ip address 10.1.1.2/30	Configure an IP address, 10.1.1.2/30, on the interface xe1.

`P1(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P1(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P1(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe1` for area 1.
`P1(config-if)#exit`	Exit interface mode `xe1`.
`P1(config)#commit`	Commit the transaction.
`P1(config)#interface xe2`	Enter interface mode `xe2`.
`P1(config-if)#ip address 10.1.4.2/30`	Configure an IP address, `10.1.4.2/30`, on the interface `xe2`.
`P1(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P1(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P1(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe2` for area 1.
`P1(config-if)#exit`	Exit interface mode `xe2`.
`P1(config)#commit`	Commit the transaction.
`P1(config)#interface xe3`	Enter interface mode `xe3`.
`P1(config-if)#ip address 10.1.5.2/30`	Configure an IP address, `10.1.5.2/30`, on the interface `xe3`.
`P1(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P1(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P1(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe3` for area 1.
`P1(config-if)#exit`	Exit interface mode `xe3`.
`P1(config)#commit`	Commit the transaction.
`P1(config)#interface xe4`	Enter interface mode `xe4`.
`P1(config-if)#ip address 10.1.6.2/30`	Configure an IP address, `10.1.6.2/30`, on the interface `xe4`.
`P1(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P1(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P1(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe4` for area 1.
`P1(config-if)#exit`	Exit interface mode `xe4`.
`P1(config)#commit`	Commit the transaction.

P1: ISIS Configuration

The below configuration is performed to set up ISIS on P1, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

P1(config)#router isis 1	Enter router ISIS mode.
P1(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
P1(config-router)#metric-style wide	Configure the new style of metric type as wide.
P1(config-router)#mpls traffic-eng router-id 10.10.10.5	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.5, which is used for MPLS-TE path calculations.
P1(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
P1(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
P1(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
P1(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
P1(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
P1(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
P1(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
P1(config-router)#net 49.0000.0000.0005.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
P1(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
P1(config-router)#segment-routing mpls	Enable SR ISIS.
P1(config-router)#exit	Exit router ISIS mode and return to the configure mode.
P1(config)#commit	Commit the transaction.

P2: Loopback Interface

The configuration on P2 for a loopback interface with IP address 10.10.10.6/32 secondary is set up to provide IP connectivity for the router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter the interface mode for the loopback interface lo.
P2(config-if)#ip address 10.10.10.6/32 secondary	Configure a secondary IP address, 10.10.10.6/32, on the loopback interface.
P2(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
P2(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
P2(config-if)#exit	Exit interface mode lo.
P2(config)#commit	Commit the transaction.

P2: Configure SR

The following configurations aim to activate Segment Routing (SR) on P2 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

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`P2(config)#segment-routing`	Configure segment routing on P2 device.
`P2(config-sr)#mpls sr-prefer`	Set MPLS as the preferred segment routing protocol over others.
`P2(config-sr)#exit`	Exit the router SR mode.
`P2(config)#commit`	Commit the transaction.

P2: Global LDP

The configuration on P2 for the Global LDP router, specifying router ID and targeted peer, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

`P2(config)#router ldp`	Enter the Router LDP mode.
`P2(config-router)#router-id 10.10.10.6`	Set the router ID for LDP to `10.10.10.6`.
`P2(config-router)#transport-address ipv4 10.10.10.6`	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
`P2(config-router)#exit`	Exit router LDP mode and return to the configure mode.
`P2(config)#commit`	Commit the transaction.

P2: Interface Configuration

The below configuration is performed to set up interfaces on P2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

`P2(config)#interface xe12`	Enter interface mode `xe12`.
`P2(config-if)#ip address 10.1.2.2/30`	Configure an IP address, `10.1.2.2/30`, on the interface `xe12`.
`P2(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P2(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P2(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe12` for area 1.
`P2(config-if)#exit`	Exit interface mode `xe12`.
`P2(config)#commit`	Commit the transaction.
`P2(config)#interface xe13`	Enter interface mode `xe13`.
`P2(config-if)#ip address 10.1.3.2/30`	Configure an IP address, `10.1.3.2/30`, on the interface `xe13`.
`P2(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P2(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P2(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe13` for area 1.
`P2(config-if)#exit`	Exit interface mode `xe13`.

`P2(config)#commit`	Commit the transaction.
`P2(config)#interface xe11`	Enter interface mode `xe11`.
`P2(config-if)#ip address 10.1.7.2/30`	Configure an IP address, `10.1.7.2/30`, on the interface `xe11`.
`P2(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P2(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P2(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe11` for area 1.
`P2(config-if)#exit`	Exit interface mode `xe11`.
`P2(config)#commit`	Commit the transaction.
`P2(config)#interface xe14`	Enter interface mode `xe14`.
`P2(config-if)#ip address 10.1.8.2/30`	Configure an IP address, `10.1.8.2/30`, on the interface `xe14`.
`P2(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P2(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P2(config-if)#ip router isis 1`	Enable ISIS routing on an interface `xe14` for area 1.
`P2(config-if)#exit`	Exit interface mode `xe14`.
`P2(config)#commit`	Commit the transaction.

P2: ISIS Configuration

The below configuration is performed to set up ISIS on P2, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

`P2(config)#router isis 1`	Enter router ISIS mode.
`P2(config-router)#is-type level-1-2`	Configure IS-Type as `Level-1-2` specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
`P2(config-router)#metric-style wide`	Configure the new style of metric type as `wide`.
`P2(config-router)#mpls traffic-eng router-id 10.10.10.6`	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to `10.10.10.6`, which is used for MPLS-TE path calculations.
`P2(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE for IS-Type `Level-1` routing.
`P2(config-router)#mpls traffic-eng level-2`	Enable MPLS-TE for IS-Type `Level-2` routing.
`P2(config-router)#capability cspf`	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
`P2(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance.
`P2(config-router)#fast-reroute ti-lfa level-1 proto ipv4`	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
`P2(config-router)#fast-reroute ti-lfa level-2 proto ipv4`	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities

`P2(config-router)#bfd all-interfaces`	Configure BFD on all interfaces for fast link failure detection.
`P2(config-router)#net 49.0000.0000.0006.00`	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
`P2(config-router)#isis segment-routing global block 17000 23500`	Enable ISIS SR globally and allocates label blocks for Segment Routing.
`P2(config-router)#segment-routing mpls`	Enable SR ISIS.
`P2(config-router)#exit`	Exit router ISIS mode and return to the configure mode.
`P2(config)#commit`	Commit the transaction.

PE3: Loopback Interface

The configuration on PE3 for a loopback interface with IP address `10.10.10.3/32` secondary is set up to provide IP connectivity for the router.

`PE3#configure terminal`	Enter configure mode.
`PE3(config)#interface lo`	Enter the interface mode for the loopback interface `lo`.
`PE3(config-if)#ip address 10.10.10.3/32 secondary`	Configure a secondary IP address, `10.10.10.3/32`, on the loopback interface.
`PE3(config-if)#ip router isis 1`	Enable ISIS routing on a loopback interface `lo` for area 1.
`PE3(config-if)#prefix-sid index 800`	Configure a prefix segment identifier (prefix-SID) index value as `800`.
`PE3(config-if)#exit`	Exit interface mode `lo`.
`PE3(config)#commit`	Commit the transaction.

PE3: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE3 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

`PE3(config)#segment-routing`	Configure segment routing on PE3 device.
`PE3(config-sr)#mpls sr-prefer`	Set MPLS as the preferred segment routing protocol over others.
`PE3(config-sr)#exit`	Exit the router SR mode.
`PE3(config)#commit`	Commit the transaction.

PE3: Global LDP

The configuration on PE3 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

`PE3(config)#router ldp`	Enter the Router LDP mode.
`PE3(config-router)#router-id 10.10.10.3`	Set the router ID for LDP to `10.10.10.3`.
`PE2(config-router)#transport-address ipv4 10.10.10.3`	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.

PE3(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 10.10.10.4	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: Global EVPN MPLS Command

The configuration on PE3 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE3(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE3, enabling it to participate in EVPN MPLS services.
PE3(config)#commit	Commit candidate configuration to be running configuration.
PE3(config)#evpn mpls vtep-ip-global 10.10.10.3	Configure the global VTEP IP address 10.10.10.3, associating it with the loopback IP.
PE3(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE3(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE3 to support multi-homed EVPN MPLS services.
PE3(config)#commit	Commit the transaction.

PE3: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE3 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE3(config)#interface xe1	Enter interface mode xe1.
PE3(config-if)#ip address 10.1.6.1/30	Configure an IP address, 10.1.6.1/30, on the interface xe1.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#ip router isis 1	Enable ISIS routing on an interface xe1 for area 1.
PE3(config-if)#exit	Exit interface mode xe1.
PE3(config)#commit	Commit the transaction.
PE3(config)#interface xe5	Enter interface mode xe5.

PE3(config-if)#ip address 10.1.7.1/30	Configure an IP address, 10.1.7.1/30, on the interface xe5.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#ip router isis 1	Enable ISIS routing on an interface xe5 for area 1.
PE3(config-if)#exit	Exit interface mode xe5.
PE3(config)#commit	Commit the transaction.

PE3: ISIS Configuration

The below configuration is performed to set up ISIS on PE3, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE3(config)#router isis 1	Enter router ISIS mode.
PE3(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE3(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE3(config-router)#mpls traffic-eng router-id 10.10.10.3	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.3, which is used for MPLS-TE path calculations.
PE3(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE3(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE3(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE3(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE3(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE3(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE3(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE3(config-router)#net 49.0000.0000.0003.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE3(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE3(config-router)#segment-routing mpls	Enable SR ISIS.
PE3(config-router)#exit	Exit router ISIS mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: BGP Configuration

The below BGP configuration on PE3 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE3(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE3(config-router)#bgp router-id 10.10.10.3	Configure BGP router ID 10.10.10.3, identifying PE3 within the BGP network.
PE3(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.4 remote-as 65010	Configure neighbor 10.10.10.4 as an iBGP neighbor with their remote AS number 65010.
PE3(config-router)#neighbor 10.10.10.4 update-source lo	Configure neighbor 10.10.10.4 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.4 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE3(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#neighbor 10.10.10.4 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE3(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE3(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 10.10.10.4 activate	Activate EVPN for iBGP neighbor 10.10.10.4 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE3(config-router)#commit	Commit the transaction.
PE3(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE3: MAC VRF Configuration

The below MAC VRF configuration on PE3 is carried out to define and set up VRFs named vrf2 and vpls1001 with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE3(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE3(config-vrf)#rd 10.10.10.3:1700	Configure Route-Distinguisher value of 10.10.10.3:1700.
PE3(config-vrf)#route-target both 1700:1700	Configure import and export values for the vrf2 as 1700:1700.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#mac vrf vpls1001	Enter VRF mode named vpls1001.
PE3(config-vrf)#rd 10.10.10.3:1001	Configure Route-Distinguisher value of 10.10.10.3:1001.
PE3(config-vrf)#route-target both 1001:1001	Configure import and export values for the vpls1001 as 1001:1001.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE3 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

PE3(config)#evpn mpls id 1700 xconnect target-mpls-id 1800	Configure the EVPN-VPWS identifier with a source identifier of 1700 and a target identifier of 1800.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
PE3(config)#evpn mpls id 3000	Configure the EVPN-VPLS identifier an identifier of 3000.
PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001	Map VRF vpls1001 to the EVPN-VPWS identifier
PE3(config-evpn-mpls)#commit	Commit the transaction.
PE3(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE3 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

PE3(config)#interface po1	Enter the port channel interface mode for po1
PE3(config-if)#load-interval 30	Set the load interval to 30.
PE3(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active	Configure the system-mac address 0000.2222.7777 for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE3(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE3(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE3(config-if)#exit	Exit interface mode po1 and return to the configure mode.

`PE3(config)#commit`	Commit the transaction.
`PE3(config)#interface po1.1 switchport`	Create a Layer 2 sub-interface `po1.1` within the port channel.
`PE3(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE3(config-if)#load-interval 30`	Set the load interval to `30`.
`PE3(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE3(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE3(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE3(config-if)#exit`	Exit interface mode `po1.1` and return to the configure mode.
`PE3(config)#interface xe2`	Enter the interface mode for `xe2`.
`PE3(config-if)#speed 10g`	Set the speed to `10g`.
`PE3(config-if)#channel-group 1 mode active`	Attach LAG interface `po1`.
`PE3(config-if)#exit`	Exit interface mode `xe2` and return to the configure mode.
`PE3(config)#commit`	Commit the transaction.

PE3: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE3 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

`PE3(config)#interface sa1`	Enter the single active interface mode for `sa1`.
`PE3(config-if)#load-interval 30`	Set the load interval to `30`.
`PE3(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active`	Configure the ESI with the value with the value `00:00:22:22:77:77` for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE3(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE3(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE3(config-if)#exit`	Exit interface mode `sa1` and return to the configure mode.
`PE3(config)#commit`	Commit the transaction.
`PE3(config)#interface sa1.1 switchport`	Create a Layer 2 sub-interface `sa1.1` within the port channel.
`PE3(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.
`PE3(config-if)#load-interval 30`	Set the load interval to `30`.
`PE3(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE3(config-acc-if-evpn)#map vpn-id 1800`	Map VPN-ID `1800`.
`PE3(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE3(config-if)#exit`	Exit interface mode `sa1.1` and return to the configure mode.
`PE3(config)#interface xe2`	Enter the interface mode for `xe2`.
`PE3(config-if)#speed 10g`	Set the speed to `10g`.
`PE3(config-if)#static-channel-group 1`	Attach the static-channel-group 1, the LAG interface `sa1` to `xe2`.

PE3(config-if)#exit	Exit interface mode xe2 and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE4: Loopback Interface

The configuration on PE4 for a loopback interface with IP address 10.10.10.4/32 secondary is set up to provide IP connectivity for the router.

PE4#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE4(config-if)#ip address 10.10.10.4/32 secondary	Configure a secondary IP address, 10.10.10.4/32, on the loopback interface.
PE4(config-if)#ip router isis 1	Enable ISIS routing on a loopback interface lo for area 1.
PE4(config-if)#prefix-sid index 800	Configure a prefix segment identifier (prefix-SID) index value as 800.
PE4(config-if)#exit	Exit interface mode lo.
PE4(config)#commit	Commit the transaction.

PE4: Configure SR

The following configurations aim to activate Segment Routing (SR) on PE4 and make MPLS the preferred method for segment routing, optimizing routing efficiency.

PE4(config)#segment-routing	Configure segment routing on PE4 device.
PE4(config-sr)#mpls sr-prefer	Set MPLS as the preferred segment routing protocol over others.
PE4(config-sr)#exit	Exit the router SR mode.
PE4(config)#commit	Commit the transaction.

PE4: Global LDP

The configuration on PE4 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE4(config)#router ldp	Enter the Router LDP mode.
PE4(config-router)#router-id 10.10.10.4	Set the router ID for LDP to 10.10.10.4.
PE4(config-router)#transport-address ipv4 10.10.10.4	Configure the transport address for IPv4 (for IPv6 use ipv6 parameter) to be used for a TCP session where LDP operates. Note: It is preferable to use the loopback address as the transport address.
PE4(config-router)#targeted-peer ipv4 10.10.10.1	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#targeted-peer ipv4 10.10.10.2	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.

PE4(config-router)#targeted-peer ipv4 10.10.10.3	Configure targeted peer for LDP using IPv4 addresses.
PE4(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE4(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: Global EVPN MPLS Command

The configuration on PE4 for the Global EVPN MPLS, includes activating EVPN MPLS, defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multi-homing, and activating EVPN MPLS multi-homing functionality, all of which are crucial for enabling EVPN MPLS features.

PE4(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE4, enabling it to participate in EVPN MPLS services.
PE4(config)#commit	Commit candidate configuration to be running configuration.
PE4(config)#evpn mpls vtep-ip-global 10.10.10.4	Configure the global VTEP IP address 10.10.10.4, associating it with the loopback IP.
PE4(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multi-homing.
PE4(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multi-homing functionality, allowing PE4 to support multi-homed EVPN MPLS services.
PE4(config)#commit	Commit the transaction.

PE4: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE4 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE4(config)#interface xe2	Enter interface mode xe2.
PE4(config-if)#ip address 10.1.5.1/30	Configure an IP address, 10.1.5.1/30, on the interface xe2.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE4(config-if)#ip router isis 1	Enable ISIS routing on an interface xe2 for area 1.
PE4(config-if)#exit	Exit interface mode xe2.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface xe0	Enter interface mode xe0.
PE4(config-if)#ip address 10.1.8.1/30	Configure an IP address, 10.1.8.1/30, on the interface xe0.
PE4(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE4(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.

PE4(config-if)#ip router isis 1	Enable ISIS routing on an interface xe2 for area 1.
PE4(config-if)#exit	Exit interface mode xe0.
PE4(config)#commit	Commit the transaction.

PE4: ISIS Configuration

The below configuration is performed to set up ISIS on PE4, to enable MPLS Traffic Engineering, Segment Routing, and other related features for efficient routing and network management.

PE4(config)#router isis 1	Enter router ISIS mode.
PE4(config-router)#is-type level-1-2	Configure IS-Type as Level-1-2 specifies that the router will participate in both Level-1 and Level-2 areas within the ISIS network.
PE4(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE4(config-router)#mpls traffic-eng router-id 10.10.10.4	Configure the router's MPLS Traffic Engineering (TE) router ID TLV to 10.10.10.4, which is used for MPLS-TE path calculations.
PE4(config-router)#mpls traffic-eng level-1	Enable MPLS-TE for IS-Type Level-1 routing.
PE4(config-router)#mpls traffic-eng level-2	Enable MPLS-TE for IS-Type Level-2 routing.
PE4(config-router)#capability cspf	Enable Constraint Shortest Path First (CSPF) computation for traffic engineering.
PE4(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE4(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE4(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Configure Remote Loop-Free Alternate (LFA) to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
PE4(config-router)#bfd all-interfaces	Configure BFD on all interfaces for fast link failure detection.
PE4(config-router)#net 49.0000.0000.0004.00	Set a Network Entity Title (NET) for this ISIS instance, specifying the area address and the system ID.
PE4(config-router)#isis segment-routing global block 17000 23500	Enable ISIS SR globally and allocates label blocks for Segment Routing.
PE4(config-router)#segment-routing mpls	Enable SR ISIS.
PE4(config-router)#exit	Exit router ISIS mode and return to configure mode.
PE4(config)#commit	Commit the transaction.

PE4: BGP Configuration

The below BGP configuration on PE4 is established to enable BGP routing with ASN 65010, set the BGP router ID, define iBGP neighbors, configure BFD, and enable the EVPN address family for efficient routing in an EVPN environment.

PE4(config)#router bgp 65010	Enter the Router BGP mode, ASN: 65010
PE4(config-router)#bgp router-id 10.10.10.4	Configure BGP router ID 10.10.10.4, identifying PE4 within the BGP network.
PE4(config-router)#neighbor 10.10.10.1 remote-as 65010	Configure neighbor 10.10.10.1 as an iBGP neighbor with their remote AS number 65010.

PE4(config-router)#neighbor 10.10.10.1 update-source lo	Configure neighbor 10.10.10.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.2 remote-as 65010	Configure neighbor 10.10.10.2 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.2 update-source lo	Configure neighbor 10.10.10.2 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.3 remote-as 65010	Configure neighbor 10.10.10.3 as an iBGP neighbor with their remote AS number 65010.
PE4(config-router)#neighbor 10.10.10.3 update-source lo	Configure neighbor 10.10.10.3 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE4(config-router)#neighbor 10.10.10.1 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.2 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.3 fall-over bfd multihop	Configure BFD for the BGP neighbor to provide rapid failure detection.
PE4(config-router)#neighbor 10.10.10.1 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#neighbor 10.10.10.2 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#neighbor 10.10.10.3 advertisement-interval 0	Configure advertisement interval for the neighbor, allowing more frequent BGP updates.
PE4(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE4(config-router-af)#neighbor 10.10.10.1 activate	Activate EVPN for iBGP neighbor 10.10.10.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#neighbor 10.10.10.2 activate	Activate EVPN for iBGP neighbor 10.10.10.2 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#neighbor 10.10.10.3 activate	Activate EVPN for iBGP neighbor 10.10.10.3 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE4(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE4(config-router)#commit	Commit the transaction.
PE4(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE4: MAC VRF Configuration

The below MAC VRF configuration on PE4 is carried out to define and set up VRFs named vrf2 and vpls1001 with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE4(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE4(config-vrf)#rd 10.10.10.4:1700	Configure Route-Distinguisher value of 10.10.10.4:1700.

`PE4(config-vrf)#route-target both 1700:1700`	Configure import and export values for the `vrf2` as `1700:1700`.
`PE4(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE4(config)#mac vrf vpls1001`	Enter VRF mode named `vpls1001`.
`PE4(config-vrf)#rd 10.10.10.4:1001`	Configure Route-Distinguisher value of `10.10.10.4:1001`.
`PE4(config-vrf)#route-target both 1001:1001`	Configure import and export values for the `vpls1001` as `1001:1001`.
`PE4(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE4(config)#commit`	Commit the transaction.

PE4: EVPN and VRF Mapping

The below EVPN and VRF mapping configuration on PE4 is performed to establish mappings between EVPN identifiers and VRFs, facilitating efficient routing and connectivity in an EVPN network environment.

`PE4(config)#evpn mpls id 1700 xconnect target-mpls-id 1800`	Configure the EVPN-VPWS identifier with a source identifier of `1700` and a target identifier of `1800`.
`PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Map VRF `vrf2` to the EVPN-VPWS identifier
`PE4(config-evpn-mpls)#commit`	Commit the transaction.
`PE4(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.
`PE4(config)#evpn mpls id 3000`	Configure the EVPN-VPLS identifier an identifier of `3000`.
`PE4(config-evpn-mpls)#host-reachability-protocol evpn-bgp vpls1001`	Map VRF `vpls1001` to the EVPN-VPWS identifier
`PE4(config-evpn-mpls)#commit`	Commit the transaction.
`PE4(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

PE4: Access Port Configuration for Port-active

The below access port configuration for port-active mode on PE4 is carried out to configure various parameters including system-MAC, load balancing, service carving preferences, and EVPN settings for efficient network access and connectivity.

`PE4(config)#interface po1`	Enter the port channel interface mode for `po1`
`PE4(config-if)#load-interval 30`	Set the load interval to `30`.
`PE4(config-if)#evpn multi-homed system-mac 0000.2222.7777 load-balancing port-active`	Configure the system-mac address `0000.2222.7777` for port-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
`PE4(config-if-es)#service-carving auto`	Configure service carving as `auto`, allowing automatic determination of service distribution preferences.
`PE4(config-if-es)#exit`	Exit the EVPN ES mode and return to the configure mode.
`PE4(config-if)#exit`	Exit interface mode `po1` and return to the configure mode.
`PE4(config)#commit`	Commit the transaction.
`PE4(config)#interface po1.1 switchport`	Create a Layer 2 sub-interface `po1.1` within the port channel.
`PE4(config-if)#encapsulation dot1q 100`	Set encapsulation to dot1q with VLAN ID `100`.

PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE4(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE4(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE4(config-if)#exit	Exit interface mode po1.1 and return to the configure mode.
PE4(config)#interface xe11	Enter the interface mode for xe11.
PE4(config-if)#speed 10g	Set the speed to 10g.
PE4(config-if)#channel-group 1 mode active	Attach LAG interface po1.
PE4(config-if)#exit	Exit interface mode xe11 and return to the configure mode.
PE4(config)#commit	Commit the transaction.

PE4: Access Port Configuration for Single-active

The below access port configuration for single-active mode on PE4 is implemented to set up various parameters, including Ethernet Segment Identifier (ESI) settings, service carving preferences, and EVPN configurations, ensuring efficient network access and connectivity.

PE4(config)#interface sa2	Enter the single active interface mode for sa2.
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#evpn multi-homed esi 00:00:22:22:77:77 load-balancing single-active	Configure the ESI with the value with the value 00:00:22:22:77:77 for single-active mode, which plays a role in load balancing and enter to the EVPN Ethernet Segment (ES) mode.
PE4(config-if-es)#service-carving auto	Configure service carving as auto, allowing automatic determination of service distribution preferences.
PE4(config-if-es)#exit	Exit the EVPN ES mode and return to the configure mode.
PE4(config-if)#exit	Exit interface mode sa2 and return to the configure mode.
PE4(config)#commit	Commit the transaction.
PE4(config)#interface sa2.1 switchport	Create a Layer 2 sub-interface sa2.1 within the port channel.
PE4(config-if)#encapsulation dot1q 100	Set encapsulation to dot1q with VLAN ID 100.
PE4(config-if)#load-interval 30	Set the load interval to 30.
PE4(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE4(config-acc-if-evpn)#map vpn-id 1800	Map VPN-ID 1800.
PE4(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE4(config-if)#exit	Exit interface mode sa2.1 and return to the configure mode.
PE4(config)#interface xe11	Enter the interface mode for xe11.
PE4(config-if)#speed 10g	Set the speed to 10g.
PE4(config-if)#static-channel-group 2	Attach the static-channel-group 2, the LAG interface sa2 to xe11.
PE4(config-if)#exit	Exit interface mode xe11 and return to the configure mode.
PE4(config)#commit	Commit the transaction.

CE2

The following configuration steps under CE2 are set up to enable VLANs and configure interfaces for carrying VLAN traffic.

`CE2#configure terminal`	Enter configure mode.
`CE2(config)#bridge 1 protocol ieee vlan-bridge`	Set up `bridge 1` to use the IEEE VLAN bridge protocol.
`CE2(config)#vlan 2-100 bridge 1 state enable`	Configure VLANs from `2-100` and associate them with bridge 1.
`CE2(config)#interface xe24`	Enter interface mode `xe24`.
`CE2(config-if)#switchport`	Configure the interface `xe24` as a Layer 2 switch port.
`CE2(config-if)#bridge-group 1`	Associate `xe24` to bridge 1.
`CE2(config-if)#switchport mode trunk`	Configure `xe24` as a trunk port.
`CE2(config-if)#switchport trunk allowed vlan all`	Allow all configured VLANs on the trunk interface `xe24`.
`CE2(config-if)#exit`	Exit interface mode `xe24`.
`CE2(config)#interface po1`	Enter interface mode and configure LAG interface port-channel 1 (`po1`).
`CE2(config-if)#switchport`	Configures port-channel 1 as a Layer 2 switch port.
`CE2(config-if)#bridge-group 1`	Associate `po1` to bridge 1.
`CE2(config-if)#switchport mode trunk`	Configure `po1` as a trunk port.
`CE2(config-if)#switchport trunk allowed vlan all`	Allow all configured VLANs on the trunk port-channel `po1`.
`CE2(config-if)#exit`	Exit interface mode `po1`.
`CE2(config)#interface xe22`	Enter interface mode `xe22`.
`CE2(config-if)#lacp timeout short`	Configure LACP timeout as `short`.
`CE2(config-if)#channel-group 1 mode active`	Add member to the LAG interface.
`CE2(config-if)#exit`	Exit interface mode `xe22`.
`CE2(config-if)#interface xe23`	Enter interface mode `xe23`.
`CE2(config-if)#lacp timeout short`	Configure LACP timeout as `short`.
`CE2(config-if)#channel-group 1 mode active`	Add member to the LAG interface.
`CE2(config-if)#commit`	Commit the transaction.
`CE2(config-if)#end`	Exit interface mode `xe23` and configure mode.

EVPN SR Active-Standby MH Validation

This section provides show outputs validation for port-active mode, covering ELINE and ELAN services with SR as the underlay MPLS path.

The following show output displays the forwarding table entries on PE1, PE2, PE3, and PE4 devices in the network Figure 3-8 using the **show mpls forwarding-table** command.

```
PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP
```

```
FTN-ECMP LDP: Disabled
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id    Pri   LSP-Type     Out-Label     Out-Intf     ELC    Nexthop
   i>   10.10.10.2/32      1         4         0            Yes   LSP_DEFAULT  17700         xe2           No     10.1.2.2
   i>   10.10.10.2/32      10        23        0            No    LSP_DEFAULT  3             xe1          No     10.1.1.2
i(b)>   10.10.10.2/32      6         17        2201         Yes   LSP_DEFAULT  17700         xe1          No     10.1.1.2
   i>   10.10.10.3/32      2         6         0            Yes   LSP_DEFAULT  17400         xe2           No     10.1.2.2
   i>   10.10.10.3/32      11        24        0            No    LSP_DEFAULT  3             xe1          No     10.1.1.2
i(b)>   10.10.10.3/32      7         19        2202         Yes   LSP_DEFAULT  17400         xe1          No     10.1.1.2
i(b)>   10.10.10.3/32      9         22        2204         Yes   LSP_DEFAULT  17400         xe2           No     10.1.2.2
   i>   10.10.10.4/32      3         8         0            Yes   LSP_DEFAULT  17300         xe2           No     10.1.2.2
   i>   10.10.10.4/32      12        25        0            No    LSP_DEFAULT  3             xe1          No     10.1.1.2
i(b)>   10.10.10.4/32      8         21        2203         Yes   LSP_DEFAULT  17300         xe1          No     10.1.1.2
   i>   10.10.10.5/32      4         9         0            Yes   LSP_DEFAULT  3             xe1          No     10.1.1.2
   i>   10.10.10.5/32      13        27        0            No    LSP_DEFAULT  17600         xe2           No     10.1.2.2
   i>   10.10.10.6/32      5         15        0            Yes   LSP_DEFAULT  3             xe2           No     10.1.2.2
   i>   10.10.10.6/32      14        29        0            No    LSP_DEFAULT  17500         xe1          No     10.1.1.2

PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id    Pri   LSP-Type     Out-Label     Out-Intf     ELC    Nexthop
   i>   10.10.10.1/32      1         10        0            Yes   LSP_DEFAULT  17800         xe4          No     10.1.3.2
   i>   10.10.10.1/32      10        27        0            No    LSP_DEFAULT  3             xe5          No     10.1.4.2
i(b)>   10.10.10.1/32      6         21        2201         Yes   LSP_DEFAULT  17800         xe5          No     10.1.4.2
   i>   10.10.10.3/32      2         11        0            Yes   LSP_DEFAULT  17400         xe4          No     10.1.3.2
   i>   10.10.10.3/32      11        28        0            No    LSP_DEFAULT  3             xe5          No     10.1.4.2
i(b)>   10.10.10.3/32      7         23        2202         Yes   LSP_DEFAULT  17400         xe5          No     10.1.4.2
i(b)>   10.10.10.3/32      9         26        2204         Yes   LSP_DEFAULT  17400         xe4          No     10.1.3.2
   i>   10.10.10.4/32      3         12        0            Yes   LSP_DEFAULT  17300         xe4          No     10.1.3.2
   i>   10.10.10.4/32      12        29        0            No    LSP_DEFAULT  3             xe5          No     10.1.4.2
i(b)>   10.10.10.4/32      8         25        2203         Yes   LSP_DEFAULT  17300         xe5          No     10.1.4.2
   i>   10.10.10.5/32      4         13        0            Yes   LSP_DEFAULT  3             xe5          No     10.1.4.2
   i>   10.10.10.5/32      13        31        0            No    LSP_DEFAULT  17600         xe4          No     10.1.3.2
   i>   10.10.10.6/32      5         19        0            Yes   LSP_DEFAULT  3             xe4          No     10.1.3.2
   i>   10.10.10.6/32      14        33        0            No    LSP_DEFAULT  17500         xe5          No     10.1.4.2


PE3#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id    Pri   LSP-Type     Out-Label     Out-Intf     ELC    Nexthop
   i>   10.10.10.1/32      1         4         0            Yes   LSP_DEFAULT  17800         xe5          No     10.1.7.2
   i>   10.10.10.1/32      10        23        0            No    LSP_DEFAULT  3             xe1          No     10.1.6.2
i(b)>   10.10.10.1/32      6         17        2201         Yes   LSP_DEFAULT  17800         xe1          No     10.1.6.2
i(b)>   10.10.10.1/32      9         22        2204         Yes   LSP_DEFAULT  17800         xe5          No     10.1.7.2
   i>   10.10.10.2/32      2         6         0            Yes   LSP_DEFAULT  17700         xe5          No     10.1.7.2
   i>   10.10.10.2/32      11        24        0            No    LSP_DEFAULT  3             xe1          No     10.1.6.2
i(b)>   10.10.10.2/32      7         19        2202         Yes   LSP_DEFAULT  17700         xe1          No     10.1.6.2
   i>   10.10.10.4/32      3         8         0            Yes   LSP_DEFAULT  17300         xe5          No     10.1.7.2
   i>   10.10.10.4/32      12        25        0            No    LSP_DEFAULT  3             xe1          No     10.1.6.2
i(b)>   10.10.10.4/32      8         21        2203         Yes   LSP_DEFAULT  17300         xe1          No     10.1.6.2
   i>   10.10.10.5/32      4         9         0            Yes   LSP_DEFAULT  3             xe1          No     10.1.6.2
   i>   10.10.10.5/32      13        27        0            No    LSP_DEFAULT  17600         xe5          No     10.1.7.2
   i>   10.10.10.6/32      5         15        0            Yes   LSP_DEFAULT  3             xe5          No     10.1.7.2
   i>   10.10.10.6/32      14        29        0            No    LSP_DEFAULT  17500         xe1          No     10.1.6.2

PE4#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP
```

```
FTN-ECMP LDP: Disabled
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type      Out-Label     Out-Intf    ELC    Nexthop
   i>   10.10.10.1/32      1         4         0           Yes   LSP_DEFAULT   17800         xe0         No     10.1.8.2
   i>   10.10.10.1/32      10        23        0           No    LSP_DEFAULT   3             xe2         No     10.1.5.2
i(b)>   10.10.10.1/32      6         17        2201        Yes   LSP_DEFAULT   17800         xe2         No     10.1.5.2
   i>   10.10.10.2/32      2         6         0           Yes   LSP_DEFAULT   17700         xe0         No     10.1.8.2
   i>   10.10.10.2/32      11        24        0           No    LSP_DEFAULT   3             xe2         No     10.1.5.2
i(b)>   10.10.10.2/32      7         19        2202        Yes   LSP_DEFAULT   17700         xe2         No     10.1.5.2
   i>   10.10.10.3/32      3         8         0           Yes   LSP_DEFAULT   17400         xe0         No     10.1.8.2
   i>   10.10.10.3/32      12        25        0           No    LSP_DEFAULT   3             xe2         No     10.1.5.2
i(b)>   10.10.10.3/32      8         21        2203        Yes   LSP_DEFAULT   17400         xe2         No     10.1.5.2
i(b)>   10.10.10.3/32      9         22        2204        Yes   LSP_DEFAULT   17400         xe0         No     10.1.8.2
   i>   10.10.10.5/32      4         9         0           Yes   LSP_DEFAULT   3             xe2         No     10.1.5.2
   i>   10.10.10.5/32      13        27        0           No    LSP_DEFAULT   17600         xe0         No     10.1.8.2
   i>   10.10.10.6/32      5         15        0           Yes   LSP_DEFAULT   3             xe0         No     10.1.8.2
   i>   10.10.10.6/32      14        29        0           No    LSP_DEFAULT   17500         xe2         No     10.1.5.2
```

The following show output displays the FEC-To-NHLF (FTN) table information on PE1, PE2, PE3, and PE4 devices in the network Figure 3-8 using the **show mpls ftn-table** command.

```
PE1#show mpls ftn-table
 Primary FTN entry with FEC: 10.10.10.2/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17700
    Nexthop addr: 10.1.2.2        cross connect ix: 7, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.2/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 6

 Primary FTN entry with FEC: 10.10.10.2/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 16
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17700
    Nexthop addr: 10.1.1.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 10.10.10.3/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17400
    Nexthop addr: 10.1.2.2        cross connect ix: 3, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.3/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 7

 Primary FTN entry with FEC: 10.10.10.3/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18
```

```
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17400
    Nexthop addr: 10.1.1.2        cross connect ix: 8, op code: Push


 Primary FTN entry with FEC: 10.10.10.3/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17400
    Nexthop addr: 10.1.2.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 10.10.10.4/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17300
    Nexthop addr: 10.1.2.2        cross connect ix: 4, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.4/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 8

 Primary FTN entry with FEC: 10.10.10.4/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 20
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17300
    Nexthop addr: 10.1.1.2        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 2, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 26
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 26, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe2, transport out intf: N/A, out label: 17600
    Nexthop addr: 10.1.2.2        cross connect ix: 10, op code: Push and Lookup

  bypass_ftn_ix 9

 Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 10.1.2.2        cross connect ix: 6, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
```

```
     Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 28
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 28, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe1, transport out intf: N/A, out label: 17500
    Nexthop addr: 10.1.1.2        cross connect ix: 11, op code: Push and Lookup

  bypass_ftn_ix 7

PE2#show mpls ftn-table
 Primary FTN entry with FEC: 10.10.10.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 16
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17800
    Nexthop addr: 10.1.3.2        cross connect ix: 7, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.1/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 10.1.4.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 6

 Primary FTN entry with FEC: 10.10.10.1/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 20
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17800
    Nexthop addr: 10.1.4.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 10.10.10.3/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 17
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17400
    Nexthop addr: 10.1.3.2        cross connect ix: 3, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.3/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 10.1.4.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 7

 Primary FTN entry with FEC: 10.10.10.3/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 22
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 22, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17400
    Nexthop addr: 10.1.4.2        cross connect ix: 8, op code: Push


 Primary FTN entry with FEC: 10.10.10.3/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 17
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17400
    Nexthop addr: 10.1.3.2        cross connect ix: 3, op code: Push
```

```
 Primary FTN entry with FEC: 10.10.10.4/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 18
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 17300
    Nexthop addr: 10.1.3.2        cross connect ix: 4, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.4/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 10.1.4.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 8

 Primary FTN entry with FEC: 10.10.10.4/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 24
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 24, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17300
    Nexthop addr: 10.1.4.2        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 10.1.4.2        cross connect ix: 2, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 30
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 30, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe4, transport out intf: N/A, out label: 17600
    Nexthop addr: 10.1.3.2        cross connect ix: 10, op code: Push and Lookup

  bypass_ftn_ix 9

 Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 15
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 15, owner: N/A, Stale: NO, out intf: xe4, out label: 3
    Nexthop addr: 10.1.3.2        cross connect ix: 6, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 32
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 32, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe5, transport out intf: N/A, out label: 17500
    Nexthop addr: 10.1.4.2        cross connect ix: 11, op code: Push and Lookup

  bypass_ftn_ix 7

PE3#show mpls ftn-table
 Primary FTN entry with FEC: 10.10.10.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17800
```

```
   Nexthop addr: 10.1.7.2       cross connect ix: 7, op code: Push


Non-primary FTN entry with FEC: 10.10.10.1/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
     Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
   Nexthop addr: 10.1.6.2       cross connect ix: 2, op code: Push

 bypass_ftn_ix 6

Primary FTN entry with FEC: 10.10.10.1/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 16
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17800
   Nexthop addr: 10.1.6.2       cross connect ix: 5, op code: Push


Primary FTN entry with FEC: 10.10.10.1/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17800
   Nexthop addr: 10.1.7.2       cross connect ix: 7, op code: Push


Primary FTN entry with FEC: 10.10.10.2/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
    Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17700
   Nexthop addr: 10.1.7.2       cross connect ix: 3, op code: Push


Non-primary FTN entry with FEC: 10.10.10.2/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
     Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
   Nexthop addr: 10.1.6.2       cross connect ix: 2, op code: Push

 bypass_ftn_ix 7

Primary FTN entry with FEC: 10.10.10.2/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17700
   Nexthop addr: 10.1.6.2       cross connect ix: 8, op code: Push


Primary FTN entry with FEC: 10.10.10.4/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
    Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe5, out label: 17300
   Nexthop addr: 10.1.7.2       cross connect ix: 4, op code: Push


Non-primary FTN entry with FEC: 10.10.10.4/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
     Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
      Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.6.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 8

 Primary FTN entry with FEC: 10.10.10.4/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 20
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe1, out label: 17300
    Nexthop addr: 10.1.6.2        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.6.2        cross connect ix: 2, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 26
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 26, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe5, transport out intf: N/A, out label: 17600
    Nexthop addr: 10.1.7.2        cross connect ix: 10, op code: Push and Lookup

  bypass_ftn_ix 9

 Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 10.1.7.2        cross connect ix: 6, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 28
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 28, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe1, transport out intf: N/A, out label: 17500
    Nexthop addr: 10.1.6.2        cross connect ix: 11, op code: Push and Lookup

  bypass_ftn_ix 7

PE4#show mpls ftn-table
 Primary FTN entry with FEC: 10.10.10.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 12
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17800
    Nexthop addr: 10.1.8.2        cross connect ix: 7, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.1/32, id: 10, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 10.1.5.2        cross connect ix: 2, op code: Push

  bypass_ftn_ix 6

 Primary FTN entry with FEC: 10.10.10.1/32, id: 6, row status: Active, Tunnel-Policy: N/A, State: Installed
```

```
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 16
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17800
   Nexthop addr: 10.1.5.2        cross connect ix: 5, op code: Push


Primary FTN entry with FEC: 10.10.10.2/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
    Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 13
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 13, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17700
   Nexthop addr: 10.1.8.2        cross connect ix: 3, op code: Push


Non-primary FTN entry with FEC: 10.10.10.2/32, id: 11, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
     Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
   Nexthop addr: 10.1.5.2        cross connect ix: 2, op code: Push

 bypass_ftn_ix 7

Primary FTN entry with FEC: 10.10.10.2/32, id: 7, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 18, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17700
   Nexthop addr: 10.1.5.2        cross connect ix: 8, op code: Push


Primary FTN entry with FEC: 10.10.10.3/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
    Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17400
   Nexthop addr: 10.1.8.2        cross connect ix: 4, op code: Push


Non-primary FTN entry with FEC: 10.10.10.3/32, id: 12, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
     Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
   Nexthop addr: 10.1.5.2        cross connect ix: 2, op code: Push

 bypass_ftn_ix 8

Primary FTN entry with FEC: 10.10.10.3/32, id: 8, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 20
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, out intf: xe2, out label: 17400
   Nexthop addr: 10.1.5.2        cross connect ix: 9, op code: Push


Primary FTN entry with FEC: 10.10.10.3/32, id: 9, row status: Active, Tunnel-Policy: N/A, State: Installed
 Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 2204, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 14
     Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, out intf: xe0, out label: 17400
   Nexthop addr: 10.1.8.2        cross connect ix: 4, op code: Push
```

```
 Primary FTN entry with FEC: 10.10.10.5/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 10.1.5.2        cross connect ix: 2, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.5/32, id: 13, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 26
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 26, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe0, transport out intf: N/A, out label: 17600
    Nexthop addr: 10.1.8.2        cross connect ix: 10, op code: Push and Lookup

  bypass_ftn_ix 9

 Primary FTN entry with FEC: 10.10.10.6/32, id: 5, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe0, out label: 3
    Nexthop addr: 10.1.8.2        cross connect ix: 6, op code: Push


 Non-primary FTN entry with FEC: 10.10.10.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State: Installed
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Backup, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 28
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 28, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: xe2, transport out intf: N/A, out label: 17500
    Nexthop addr: 10.1.5.2        cross connect ix: 11, op code: Push and Lookup

  bypass_ftn_ix 8
```

Port-Active

The following show output displays the Ethernet Segment (ES) and Intermediate System (IS) neighbor adjacencies for PE1, PE2, PE3, PE4, P1, and P2 devices in the network Figure 3-8 using the **show clns neighbors** command.

```
PE1#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P2             xe2         e8c5.7a55.3c7e      Up     22        L1   IS-IS
                                               Up     22        L2   IS-IS
P1             xe1        e49d.73b3.c107      Up     23        L1   IS-IS

PE2#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P2             xe4         e8c5.7a55.3c7f      Up     8         L1   IS-IS
                                               Up     8         L2   IS-IS
P1             xe5         e49d.73b3.c14c      Up     29        L1   IS-IS
                                               Up     29        L2   IS-IS
                                                       Up     23        L2   IS-IS

P1#show clns neighbors

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8
```

```
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
PE3            xe4         b86a.97d9.2cdf      Up     19        L1   IS-IS
                                               Up     19        L2   IS-IS
PE2            xe2       e8c5.7a47.9dfc      Up     7         L1   IS-IS
                                               Up     7         L2   IS-IS
PE1            xe1         e8c5.7a78.c918      Up     7         L1   IS-IS
                                               Up     7         L2   IS-IS
PE4            xe3       d077.ceda.7004      Up     19        L1   IS-IS
                                               Up     19        L2   IS-IS

P2#show clns neighbors

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
PE3            xe11         b86a.97d9.2ccb      Up     19        L1   IS-IS
                                               Up     19        L2   IS-IS
PE1            xe12        e8c5.7a78.c908      Up     7         L1   IS-IS
                                               Up     7         L2   IS-IS
PE2            xe13        e8c5.7a47.9dfb      Up     19        L1   IS-IS
                                               Up     19        L2   IS-IS
PE4            xe14        d077.ceda.7002      Up     19        L1   IS-IS
                                               Up     19        L2   IS-IS


PE3#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P2             xe5         e8c5.7a55.3c77      Up     7         L1   IS-IS
                                               Up     7         L2   IS-IS
P1             xe1         e49d.73b3.c105      Up     5         L1   IS-IS
                                               Up     5         L2   IS-IS

PE4#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P2             xe0         e8c5.7a55.3c80      Up     5         L1   IS-IS
                                               Up     5         L2   IS-IS
P1             xe2         e49d.73b3.c14d      Up     6         L1   IS-IS
                                               Up     6         L2   IS-IS
```

Port-Active ELAN

The following show outputs provide validation for ELAN configurations.

The following show output displays the EVPN active multi-homed and load-balanced details on PE1, PE2, PE3, and PE4 devices in the network Figure 3-8 using the **show evpn load-balance port-active** and **show evpn multi-homing all** commands.

```
PE1#show evpn load-balance port-active
ESI                          AC-IF/PE     PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
=========================================================================================================================
=========
00:00:00:11:11:77:77:00:00:00  LOCAL        10.10.10.1       port-active       auto              0        NO         NA
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE       10.10.10.2       port-active       auto              0        NO         NA
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE       10.10.10.3       port-active       ----              ----     ----       ----
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE       10.10.10.4       port-active       ----              ----     ----       ----
ACTIVE
```

```
PE2#show evpn load-balance port-active
ESI                           AC-IF/PE    PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.1       port-active       auto               0        NO          NA
STANDBY
00:00:00:11:11:77:77:00:00:00  LOCAL       10.10.10.2       port-active       auto               0        NO          NA
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE      10.10.10.3       port-active       ----               ----     ----        ----
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE      10.10.10.4       port-active       ----               ----     ----        ----
ACTIVE

PE3#show evpn load-balance port-active
ESI                           AC-IF/PE    PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.1       port-active       ----               ----     ----        ----
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.2       port-active       ----               ----     ----        ----
ACTIVE
00:00:00:22:22:77:77:00:00:00  LOCAL       10.10.10.3       port-active       auto               0        NO          NA
STANDBY
00:00:00:22:22:77:77:00:00:00  REMOTE      10.10.10.4       port-active       auto               0        NO          NA
ACTIVE

PE4#show evpn load-balance port-active
ESI                           AC-IF/PE    PE-IP-ADDRESS    Redundancy        Service-carving    weight   Revertive  AC-DF
Status
==============================================================================================================================
=========
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.1       port-active       ----               ----     ----        ----
STANDBY
00:00:00:11:11:77:77:00:00:00  REMOTE      10.10.10.2       port-active       ----               ----     ----        ----
ACTIVE
00:00:00:22:22:77:77:00:00:00  REMOTE      10.10.10.3       port-active       auto               0        NO          NA
STANDBY
00:00:00:22:22:77:77:00:00:00  LOCAL       10.10.10.4       port-active       auto               0        NO          NA
ACTIVE

PE1#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  po1          10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.4
Total number of entries are 4

PE2#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.1
00:00:00:11:11:77:77:00:00:00  po1          10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.4
Total number of entries are 4

PE3#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.2
00:00:00:22:22:77:77:00:00:00  po1          10.10.10.3
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.4
Total number of entries are 4

PE4#show evpn multi-homing all
ESI                            Access-IF    PE-IP-ADDRESS
===========================================================
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.1
00:00:00:11:11:77:77:00:00:00  ----         10.10.10.2
00:00:00:22:22:77:77:00:00:00  ----         10.10.10.3
```

```
00:00:00:22:22:77:77:00:00:00  po1         10.10.10.4
Total number of entries are 4
```

The following show output displays the active EVPN MPLS Tunnels for ELAN on PE1, PE2, PE3, and PE4 devices in the network Figure 3-7 using the **show evpn mpls tunnel** command.

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down        Update         evpn-id
====================================================================================
10.10.10.1       10.10.10.2       Installed      00:02:19       00:02:19       3000
10.10.10.1       10.10.10.4       Installed      00:10:21       00:10:21       3000
10.10.10.1       10.10.10.3       Installed      00:10:47       00:10:47       3000

Total number of entries are 3

PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down        Update         evpn-id
====================================================================================
10.10.10.2       10.10.10.1       Installed      00:02:01       00:02:01       3000
10.10.10.2       10.10.10.4       Installed      00:02:01       00:02:01       3000
10.10.10.2       10.10.10.3       Installed      00:02:01       00:02:01       3000

Total number of entries are 3

PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down        Update         evpn-id
====================================================================================
10.10.10.3       10.10.10.2       Installed      00:02:27       00:02:27       3000
10.10.10.3       10.10.10.4       Installed      00:10:29       00:10:29       3000
10.10.10.3       10.10.10.1       Installed      00:10:54       00:10:54       3000

Total number of entries are 3

PE4#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down        Update         evpn
-id
=================================================================================
===
10.10.10.4       10.10.10.2       Installed      00:02:30       00:02:30       3000

10.10.10.4       10.10.10.3       Installed      00:10:32       00:10:32       3000

10.10.10.4       10.10.10.1       Installed      00:10:32       00:10:32       3000


Total number of entries are 3
```

Port-Active ELINE

The following show output displays the active EVPN SR Tunnels for ELINE on PE1, PE2, PE3, and PE4 devices in the network Figure 3-8 using the **show evpn mpls xconnect tunnel** command.

```
PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down        Update         local-evpn-id remote-evpn-id
=========================================================================================================
10.10.10.1       10.10.10.4       AC-Down        01:07:01       01:07:01       1800          1700
10.10.10.1       10.10.10.3       AC-Down        01:07:01       01:07:01       1800          1700

Total number of entries are 2

PE2#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status         Up/Down        Update         local-evpn-id remote-evpn-id
=========================================================================================================
10.10.10.2       10.10.10.3       Installed      00:08:20       00:07:31       1800          1700
10.10.10.2       10.10.10.4       Installed      00:08:20       00:07:31       1800          1700
```

```
Total number of entries are 2

PE3#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
========================================================================================================
10.10.10.3       10.10.10.1       AC-Down       01:04:48      01:04:48      1700          1800
10.10.10.3       10.10.10.2       AC-Down       00:08:48      00:08:48      1700          1800

Total number of entries are 2

PE4#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
========================================================================================================
10.10.10.4       10.10.10.1       Installed     00:09:00      00:08:28      1700          1800
10.10.10.4       10.10.10.2       Installed     00:09:01      00:08:28      1700          1800

Total number of entries are 2
```

Implementation Examples

Scenario: Customer wants to achieve redundancy for its hosts in a network using Single-Active or Port-Active redundancy.

- Customer configures the `evpn multi-homed` command with the `load-balancing single-active or load-balancing port-active` option on the relevant PE interfaces.
- Single-Active or Port-Active redundancy is now in effect, ensuring redundancy for hosts.
- The feature works in conjunction with other EVPN-related configurations, such as VRF, VLAN mapping, and other EVPN settings.

New CLI Commands

The EVPN Active-Standby feature introduces the following configuration commands. For more information of the EVPN MPLS commands, see the EVPN MPLS Commands chapter in the *Multi-Protocol Label Switching Guide*.

service-carving ac-driven

Use this command to enable the AC-influenced method for any selected Designated Forwarder (DF) algorithm.

Enabling the `ac-driven` method allows the Designated Forwarder (DF) algorithm to be influenced by the Attachment Circuits (AC's) associated with a specific Ethernet Segment (ES). This means that the DF selection is based on the AC's characteristics and conditions, such as whether an AC is operational UP, mapped, or unmapped on the ESI.

Use `no` form of this command to disable the AC-influenced method for any selected Designated Forwarder (DF) algorithm.

Command Syntax

```
service-carving ac-driven
no service-carving ac-driven
```

Parameters

None

Default

`ac-driven` is disabled.

Command Mode

EVPN Ethernet Segment (ES) Mode

Applicability

This command was introduced in the OcNOS version 6.4.2.

Example

The provided examples showcase the configuration of the `service-carving ac-driven` command in EVPN Ethernet Segment (ES) mode. The first two examples demonstrate enabling this feature with different DF election methods, and the final example illustrates the command to disable `service-carving ac-driven`.

```
OcNOS#configure terminal
OcNOS(config)#interface sa1
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#service-carving ac-driven
OcNOS(config-if-es)#end

OcNOS#configure terminal
OcNOS(config)#interface sa1
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving auto
OcNOS(config-if-es)#service-carving ac-driven

OcNOS(config-if-es)#no service-carving ac-driven
OcNOS(config-if-es)#end
```

service-carving

Use this command to provide the flexibility to select the Designated Forwarder (DF) election algorithm based on preference based or modulo-based DF election.

Use no form of this command to disable service-carving.

Command Syntax

```
service-carving (preference-based|auto)
no service-carving
```

Parameters

`preference-based`	Select the DF election algorithm based on preference based.
`auto`	Select the DF election algorithm based on modulo based.

Default

None

Command Mode

EVPN ES Mode

Applicability

This command was introduced in the OcNOS version 6.4.1.

Example

The following examples demonstrate the configuration of the `service-carving` command in both `single-active` or `port-active` mode for the EVPN multi-homed system, with one utilizing `auto` service carving and the other using `preference-based` service carving.

```
OcNOS#configure terminal
OcNOS(config)#interface sa1
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving auto
OcNOS(config-if-es)#end

OcNOS#configure terminal
OcNOS(config)#interface po1
OcNOS(config-if)#evpn multi-homed system-mac 0000.0000.0011 load-balancing
port-active
OcNOS(config-if-es)#service-carving auto
OcNOS(config-if-es)#end

OcNOS#configure terminal
OcNOS(config)#interface po1
OcNOS(config-if)#evpn multi-homed system-mac 0000.0000.0011 load-balancing
port-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#end
```

The following example is used to disable the `service-carving` for the EVPN multi-homed system.

```
OcNOS(config-if-es)#no service-carving
OcNOS(config-if-es)#end
```

service-carving weight

Use this command to specify a preference value when the preference-based Designated Forwarder (DF) election algorithm is selected. This preference value determines the priority of the local PE device to become the DF for a particular Ethernet segment.

Use no form of this command to replace the preference weight value and choose the default preference value.

Command Syntax

```
service-carving weight <1-65535>

no service-carving weight
```

Parameters

`weight <1-65535>` Specifies the preference weight value. A lower weight value indicates a higher priority for becoming the DF.

Default

The service-carving weight command is set to 32767 by default.

Command Mode

EVPN Ethernet Segment (ES) Mode

Applicability

This command was introduced in the OcNOS version 6.4.1.

Example

The `service-carving weight` command is used to configure the preference weight value for service-carving in both port-active and single-active modes.

```
OcNOS#configure terminal
OcNOS(config)#interface po1
OcNOS(config-if)#evpn multi-homed system-mac 0000.0000.0011 load-balancing
port-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#service-carving weight 100
OcNOS(config-if-es)#end

OcNOS#configure terminal
OcNOS(config)#interface sa1
OcNOS(config-if)#evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-
balancing single-active
OcNOS(config-if-es)#service-carving preference-based
OcNOS(config-if-es)#service-carving weight 100
```

To disable the configured weight, use the `no service-carving weight` command.

```
OcNOS(config-if-es)#no service-carving weight
OcNOS(config-if-es)#end
```

Revised CLI Commands

Below is the revised command for configuring EVPN Active-Standby.

evpn multi-homed

- The command `evpn multi-homed` allows users to configure single-active and port-active load-balancing Ethernet Segment Identifier (ESI) on a link with a multihomed Customer Edge (CE) in the context of EVPN multi-homed configurations. For more details, refer to the evpn multi-homed command in the EVPN MPLS Commands chapter in the Multi-Protocol Label Switching Guide.
- The existing syntax now includes the newly added parameter for load-balancing, namely `single-active and port-active`.

Troubleshooting

To ensure the reliable operation of the single-active or port-active setup and maintain data accuracy and consistency, follow these troubleshooting steps:

1. Verify the Configuration:
   - Use the `show running-config` command to confirm that the ESI configuration includes `load-balancing single-active or port-active`, such as:

     ```
     evpn multi-homed esi 11:22:33:44:55:66:77:88:99 load-balancing single-active
     or
     evpn multi-homed system-mac 0000.4321.1234 load-balancing port-active
     ```
   - Ensure that the `service-carving` algorithm type is configured.

2. Verify the `show` command:
   - Use the `show bgp l2vpn evpn multihoming es-route` command to confirm that it matches the `service-carving` algorithm type.
   - Use the `show evpn load-balance single-active or port-active` command to verify the status of the Multihomed (MH) nodes as `ACTIVE` and `STANDBY`.

3. **Ensure Proper Connectivity:** Validate the connectivity between the router and the EVPN tunnel to ensure it is up. This involves verifying network settings, ports, and firewalls.

4. **For the server:** Enable debugging on OcNOS and enable debug mode. Verify the logs in `/var/log/messages` for further insights.

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
EVPN	Ethernet Virtual Private Network
ELINE	Ethernet Line services
ELAN	Ethernet LAN services
LAN	Local Area Network
CE	Customer Edge
PE	Provider Edge
MH	Multihoming
AC	Attachment Circuit
LACP	Link Aggregation Control Protocol
BUM	Broadcast, Unknown Unicast, Multicast
MAC	Media Access Control
ARP/ND	Address Resolution Protocol/Neighbor Discovery
DF	Designated Forwarder

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Glossary

The following provides definitions for key terms used throughout this document.

Ethernet Virtual Private Network (EVPN)	A network technology that extends Layer 2 Ethernet services over a Layer 3 IP/MPLS network.
Ethernet Line services (ELINE)	Two PEs are directly connected over an Ethernet link, enabling redundancy and efficient data exchange.
Ethernet LAN services (ELAN)	A group of PEs are interconnected in a multipoint Ethernet network, providing redundancy and optimized data transfer.
Port-Active	A redundancy mechanism in which multiple Provider Edge (PE) devices can be active simultaneously for the same host or MAC address, with specific active ports associated with each active PE.
Single-Active	A redundancy mechanism in which only one of the Provider Edge (PE) devices is active at a time for handling traffic for a specific host or MAC address.
Customer Edge (CE)	A device at the customer's network edge that connects to the service provider's network.
Provider Edge (PE)	A device at the service provider's network edge that connects to customer edge devices.
Multihoming (MH)	Connecting a host or CE device to multiple PE devices for redundancy and load balancing.
Attachment Circuit (AC)	The connection between a CE device and a PE device in an EVPN network.
Link Aggregation Control Protocol (LACP)	A protocol used to manage and bundle multiple physical links into a single logical link for higher bandwidth and redundancy.
Broadcast, Unknown Unicast, Multicast (BUM)	Categories of network traffic that includes broadcast, unknown unicast, and multicast packets.
Media Access Control (MAC)	A unique identifier assigned to network interfaces, typically associated with a hardware address.
Address Resolution Protocol/Neighbor Discovery (ARP/ND)	Protocols used to map IP addresses to MAC addresses in a local network.
Designated Forwarder (DF)	A PE device selected to forward broadcast, unknown unicast, and multicast traffic within an Ethernet segment.
Redundancy	The provision of duplicate equipment or links to ensure network availability in case of failures.
Failover	The process of switching to a backup device or link in case of a primary device or link failure.
Resiliency	The ability of a network to maintain its functionality even in the face of failures or disruptions.
Unicast	Communication between a single sender and a single receiver in a network.
Multicast	Communication from a single sender to multiple receivers in a network.

Egress	The process of traffic leaving a device or network segment.
Standby	In redundancy, a secondary device or link that is ready to take over in case the primary device or link fails.
Active	In redundancy, the primary device or link that is currently handling traffic.
Forwarding	The process of transmitting network packets from one device to another.
Link State	The operational status of a network link, indicating whether it is up or down.
Virtual Routing and Forwarding (VRF)	A technology that enables multiple instances of a routing table to coexist within a router.
Virtual Local Area Network (VLAN)	A logical network segment within a physical network.
Data Exchange	The process of sending and receiving data between network devices.
Downtime	The period during which a network or service is not available due to maintenance or failures.

CHAPTER 4 EVPN MPLS E-Tree

Overview

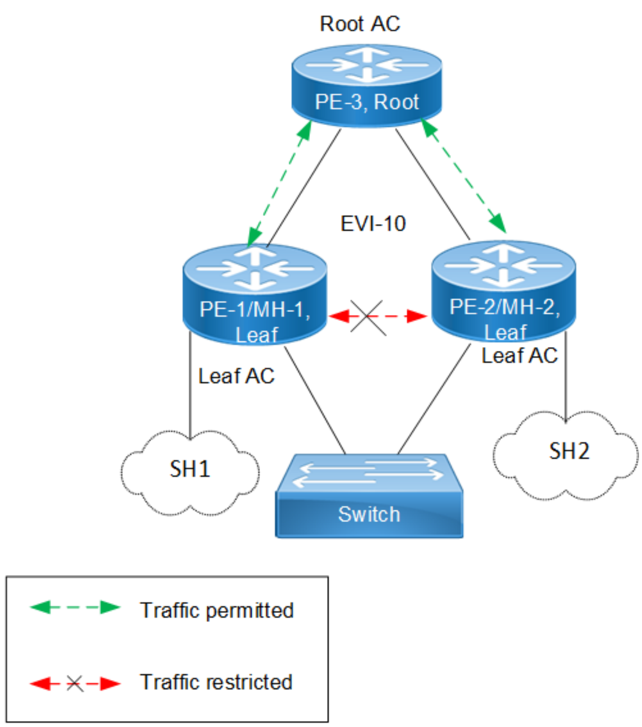
Ethernet VPN Ethernet-Tree (EVPN E-Tree), is a networking solution designed to manage communication within broadcast domains, incorporating redundancy through multi-homing in a network. It optimizes traffic routing and control, especially in scenarios where specific services or devices need controlled communication. It categorizes network nodes based on predefined definitions of EVPN Instances as Leaf or Root, allowing or restricting communication between them.

Feature Characteristics

Implemented Scenario 1 of the EVPN E-Tree solution, as defined by RFC-8317, designates each Provider Edge (PE) node as either a Leaf or a Root site per Virtual Private Network (VPN) for VXLAN and MPLS EVPN in OcNOS.

Scenario 1: Leaf or Root Site(s) per PE

Scenario 1 involves a topology with three PE nodes: PE-1, PE-2, and PE-3. PE-1 and PE-2 are Multi-Homed nodes (MH-1 and MH-2), with PE-3 acting as the Root node. PE-1 and PE-2 function as Leaf nodes and are part of a single home access interface (SH1 and SH2).



EVPN E-Tree

The classification ensures that communication follows specific rules:

- Communication between Leaf hosts is restricted, as indicated by red dotted lines with a cross mark (X) in the topology diagram. However, communication between Leaf and Root nodes, as well as between Root nodes, is permitted, marked by green dotted lines.

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- Leaf nodes within PE-1 and PE-2 are isolated from each other, preventing intra-PE communication.

The scenario 1 is achieved through two main concepts:

1. **Inter-PE Communication**
   - The inter-PE Route Target (RT) Constraint Method is applicable only to Single-Homing (SH) devices. Two RTs per broadcast domain are utilized, with Leaf PEs exporting Leaf RTs and Root nodes exporting Root RTs. Leaf nodes import only Root RTs, allowing communication with Root PEs while preventing communication with other Leaf nodes. RT constraints limit the import of specific EVPN routes (MAC-IP and IMET routes) to designated paths for inter-PE communication.
   - IPI employs a proprietary method to support inter-PE connectivity for both SH and MH devices, using BGP extended community to advertise Leaf Indication in BGP routes and influence traffic flow for both Unicast and BUM traffic. This method enables implementation of ARP or ND cache suppression and MAC mobility sub-features specified in RFC-7432.
2. **Intra-PE communication:** Local Split Horizon controls intra-PE communication between Attachment Circuits (ACs) within Leaf PE nodes, ensuring that traffic between ACs does not egress to other Leaf ACs.

   Note: This functionality depends on hardware capabilities.

Benefits

EVPN E-Tree offers benefits in networking environments by providing efficient traffic control, enhanced security, scalability, and improved performance.

Efficient Traffic Control: EVPN E-Tree allows for efficient control over traffic within network broadcast domains. By segregating nodes into Leaf and Root categories, it enables precise management of communication flows, ensuring the traffic is directed only where needed.

Enhanced Security: The isolation of Leaf hosts from each other adds a layer of security to the network. This prevents unauthorized communication between devices within the same broadcast domain, reducing the risk of data breaches and unauthorized access.

Scalability: EVPN E-Tree is scalable, making it suitable for networks of various sizes and complexities. Whether deploying in small-scale environments or large enterprise networks, EVPN E-Tree offers flexibility and scalability to meet evolving business needs.

Improved Performance: By controlling communication paths and optimizing traffic flows, EVPN E-Tree can improve network performance. This ensures that critical data packets are delivered efficiently, reducing latency and enhancing overall network performance.

Prerequisites

In setting up a MPLS EVPN network, certain prerequisites are essential to ensure proper functionality and connectivity.

Ensure MPLS EVPN Configuration: Confirm that MPLS EVPN and MPLS MH filtering are already enabled in all leaf and root nodes of the network as they are required for MPLS EVPN Multihoming.

```
!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn mpls multihoming enable
!
qos enable
```

```
!
```

Define Interfaces and Loopback Addresses: Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific system MAC addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish the efficient network routing and communication.

```
!
interface po1
 switchport
 load-interval 30
 evpn multi-homed system-mac 0000.4321.1234
!
interface lo
 ip address 8.8.8.8/32 secondary
 ip router isis ISIS-IGP
 enable-ldp ipv4
!
interface xe8
 switchport
!
interface xe26
 channel-group 1 mode active
!
```

Configure ISIS and BGP for Dynamic Routing: Enable ISIS to facilitate dynamic routing on all Leaf and Root nodes within the network. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution. Additionally, establish BGP sessions to advertise routes between different nodes. Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

```
!
router isis ISIS-IGP
 is-type level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 8.8.8.8
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0008.00
!
router bgp 65535
 neighbor 9.9.9.9 remote-as 65535
 neighbor 24.24.24.24 remote-as 65535
 neighbor 26.26.26.26 remote-as 65535
 neighbor 29.29.29.29 remote-as 65535
 neighbor 9.9.9.9 update-source lo
 neighbor 9.9.9.9 fall-over bfd
 neighbor 24.24.24.24 update-source lo
 neighbor 24.24.24.24 fall-over bfd
 neighbor 26.26.26.26 update-source lo
 neighbor 26.26.26.26 fall-over bfd
```

```
 neighbor 29.29.29.29 update-source lo
 neighbor 29.29.29.29 fall-over bfd
 !
 address-family l2vpn evpn
 neighbor 9.9.9.9 activate
 neighbor 24.24.24.24 activate
 neighbor 26.26.26.26 activate
 neighbor 29.29.29.29 activate
 exit-address-family
 !
 exit
!
```

Configure LDP and RSVP for Efficient Network Operation: Enable Label Distribution Protocol (LDP) and Resource Reservation Protocol (RSVP) on all Leaf and Root nodes to optimize traffic routing and quality of service. LDP assigns labels for packet forwarding, while RSVP reserves network resources along specified paths to enhance network performance and reliability.

```
!
router ldp
 router-id 8.8.8.8
 fast-reroute
 graceful-restart full
 graceful-restart timers neighbor-liveness 120
 graceful-restart timers max-recovery 120
 session-protection duration 10
 targeted-peer ipv4 9.9.9.9
  exit-targeted-peer-mode
 targeted-peer ipv4 24.24.24.24
  exit-targeted-peer-mode
 transport-address ipv4 8.8.8.8
!
router rsvp
!
rsvp-path LEAF1-ROOT2 mpls
 24.1.4.24 strict
!
rsvp-path LEAF1-ROOT1 mpls
 26.1.2.26 strict
!
rsvp-trunk LEAF1-ROOT1 ipv4
 primary fast-reroute protection facility
 primary path LEAF1-ROOT1
 to 9.9.9.9
!
rsvp-trunk LEAF1-ROOT2 ipv4
 primary fast-reroute protection facility
 primary path LEAF1-ROOT2
 to 24.24.24.24
!
```

Create VRF for Isolated Routing Instances: Configure VRF on all Leaf and Root nodes to create isolated routing instances within the network. This enables separate routing tables and forwarding behaviors for different groups of network resources.

```
!
mac vrf vrf103
 rd 8.8.8.8:103
 route-target both 65535:103
```

```
!
```

Connect Network Interfaces: Configure network interfaces on all Leaf and Root nodes with connection details, IP addresses, and protocol settings. Enable label-switching and configure participation in the ISIS routing protocol, including support for protocols like LDP and RSVP for IPv4. These configurations optimize routing and resource management across the network.

```
!
interface xe11
 description connected to ROOT2 int xe9
 ip address 24.1.4.25/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe20
 description connected to ROOT1 int xe20
 ip address 26.1.2.27/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
```

Configure Switch: Set up a VLAN bridge by enabling the VLAN and associating specific VLANs with the bridge. Configure network interfaces as trunk ports to allow traffic for all permitted VLANs across the network. Designate interfaces connected to Leaf and Root nodes as member ports of the VLAN bridge. This setup optimizes network segmentation and traffic management

```
!
bridge 1 protocol rstp vlan-bridge
!
vlan database
 vlan-reservation 4030-4094
 vlan 2-3010 bridge 1 state enable
!
interface po100
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan all
!
interface lo
 ip address 32.32.32.32/32 secondary
!
interface xe9
 channel-group 100 mode active
!
interface xe17
 channel-group 100 mode active
!
interface xe1
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan all
!
 exit
```

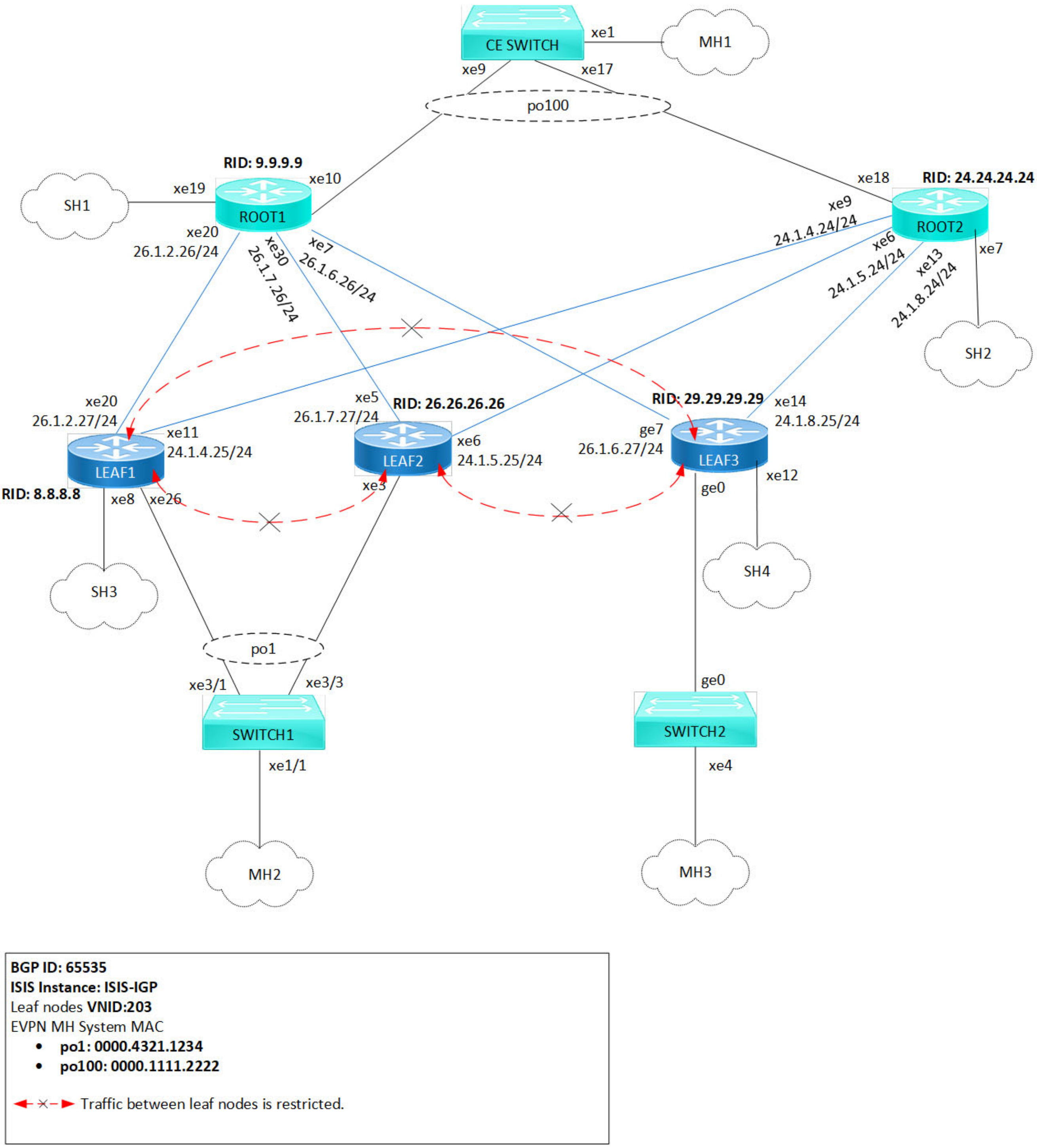
!

Configuration

Configure various nodes within the topology to set up an MPLS EVPN E-Tree network, ensuring EVPN E-Tree for All-Active and Active-Standby redundancy and load balancing.

Topology

In the sample topology, Leaf nodes (LEAF1, LEAF2, LEAF3, and LEAF4), Root nodes (ROOT1 and ROOT2), and Switches (CE SWITCH, SWITCH1, and SWITCH2) form the network architecture. LEAF1 and LEAF2 are part of a Multi-homed group, with both connected to `po1` (MH2). LEAF1 and LEAF3 have single home access-if ports (SH3 and SH4, respectively). Similarly, ROOT1 and ROOT2 are part of a Multi-homed group with `po100` (MH1), and they each have a single home access-if port (SH1 and SH2, respectively). Leaf nodes are interconnected, and CE SWITCH, SWITCH1, and SWITCH2 are configured for Multi-homed connections to Leaf and Root nodes. SWITCH1 connects to LEAF1 and LEAF2, while CE SWITCH links to ROOT1 and ROOT2.



MPLS EVPN E-Tree Topology

Note: Before configuring E-Tree, meet all Prerequisites for the following nodes:

- Leaf nodes: LEAF1, LEAF2, and LEAF3
- Root nodes: ROOT1 and ROOT2
- Switches: CE SWITCH, SWITCH1 and SWITCH2

Enable EVPN E-Tree

The following E-Tree configurations applies to Leaf and Root nodes within the MPLS network.

1. Enable EVPN E-Tree which allows the nodes to participate in E-Tree functionality within the network, controlling traffic and establishing hierarchical connections between Leaf nodes in the network architecture.

   ```
   (config)#evpn etree enable
   ```

2. Set the MAC ageing time (60 seconds) to allow MAC addresses learned over EVPN MPLS to remain in the MAC table before timing out. Configure the global VTEP IP address (8.8.8.8) which serves as the global identifier for MPLS encapsulation and decapsulation within the network, facilitating proper communication and tunnel establishment.

   ```
   (config)#evpn mpls mac-ageing-time 60
   (config)#evpn mpls vtep-ip-global 8.8.8.8
   ```

3. Define MPLS identifier (203) to support hierarchical connectivity and traffic control within the EVPN MPLS network. On the EVPN MPLS node, specify EVPN-BGP as the host reachability protocol for the specified VRF (vrf103) to communicate and exchange reachability information within the network. To enable EVPN E-Tree on Leaf nodes, configure etree-leaf along with the MPLS identifier. This allows for efficient replication of traffic at the ingress point, optimizing the functionality of E-Tree Leaf nodes within the network architecture.

   ```
   (config)#evpn mpls id 203 etree-leaf
   (config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf103
   (config-evpn-mpls)#exit
   ```

4. Enable port-VLAN mapping (po1) with VLAN ID (103) to facilitate multi-homed access. Enable EVPN functionality on the interface, allowing it to participate in MAC address distribution across the network.

   ```
   (config)#interface po1.103 switchport
   (config-if)#encapsulation dot1q 103
   (config-if)#load-interval 30
   (config-access-if)#access-if-evpn
   (config-access-if)#exit
   ```

Validation

Use the show commands described in this section to verify the network for proper MPLS EVPN E-Tree configuration.

Verify LDP sessions on all leaf and root nodes by using the show ldp session command. The state field (OPERATIONAL) indicates that the LDP session between the device and its peers is currently active.

```
LEAF1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       24.24.24.24        xe11       Passive   OPERATIONAL   30    01:13:29
       9.9.9.9            xe20       Passive   OPERATIONAL   30    01:13:29
```

Verify RSVP sessions on all leaf and root nodes by using the show rsvp session command. The State field (UP) indicates that the RSVP session between the ingress and egress routers is active and operational. Identify the different paths established within the network using the LSPName field.

```
LEAF1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

```
Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
9.9.9.9        8.8.8.8        5001     2201     PRI    LEAF1-ROOT1-Primary            UP    01:13:16  1 1 SE     -       25601
24.24.24.24    8.8.8.8        5002     2202     PRI    LEAF1-ROOT2-Primary            UP    01:13:05  1 1 SE     -       25601
Total 2 displayed, Up 2, Down 0.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
8.8.8.8        9.9.9.9         5001     2201     PRI    ROOT1-LEAF1-Primary            UP    01:13:45  1 1 SE     25600   -
8.8.8.8        24.24.24.24     5001     2201     PRI    ROOT2-LEAF1-Primary            UP    01:13:24  1 1 SE     25601   -
Total 2 displayed, Up 2, Down 0.
```

Verify the BGP session status on all leaf and root nodes, using the `show bgp l2vpn evpn summary` command output. The `Up/Down` field indicates the duration for which the BGP session has been up or down.

```
LEAF1#show bgp l2vpn evpn summary
BGP router identifier 8.8.8.8, local AS number 65535
BGP table version is 33
1 BGP AS-PATH entries
0 BGP community entries

Neighbor       V AS     MsgRcv  MsgSen  TblVer  InQ    OutQ    Up/Down  State/PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
9.9.9.9        4 65535  514     443      33      0      0      01:13:53           114      59      5     50      0          0
24.24.24.24    4 65535  504     443      33      0      0      01:13:54           109      59      0     50      0          0
26.26.26.26    4 65535  322     391      33      0      0      01:13:23            49       0      0     49      0          0
29.29.29.29    4 65535  197     392      33      0      0      01:13:54             6       0      0      6      0          0

Total number of neighbors 4

Total number of Established sessions 4
```

Verify ESI information and the forwarding tunnel status on all leaf and root nodes, by examining the `show evpn mpls` command output. The DF- Status field displays the forwarding status as either a `Designated Forwarder (DF) or Non-Designated Forwarder (Non-DF)`, and the ESI field displays the Ethernet Segment Identifier associated with each entry.

```
LEAF1#show evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN      DF-Status Src-Addr         Dst-Addr
_____________________________________________________________________________________________________________________________
203      ----         L2       NW   ----      ----                          ----      ----      8.8.8.8          29.29.29.29
203      ----         L2       NW   ----      ----                          ----      ----      8.8.8.8          9.9.9.9
203      ----         L2       NW   ----      ----                          ----      ----      8.8.8.8          24.24.24.24
203      ----         L2       NW   ----      ----                          ----      ----      8.8.8.8          26.26.26.26
203      ----         --       AC   po1.103   00:00:00:43:21:12:34:00:00:00 ----      DF        ----             ----
203      ----         --       AC   po2.103   00:00:00:33:33:44:44:00:00:00 ----      DF        ----             ----

Total number of entries are 252
```

Static MAC-IP Advertisement

Configure static MAC-IP advertisement through SH and MH from Root and Leaf nodes. Advertise static MAC addresses for both IPv4 and IPv6 from all MH and SH nodes. Ensure that nodes within the same MH have identical MAC addresses configured under the port-channel access port.

Configure MH Nodes

Configure static MAC addresses for IPv4 (`30.30.30.3`) and IPv6 (`3000::1`) under the MH access-port (`po1`) with VLAN ID (`103`). Repeat the same configurations for other MH nodes using different static MAC addresses for both IPv4 and IPv6.

```
!
interface po1.103 switchport
 access-if-evpn
  map vpn-id 203
  mac 0000.7777.9999
  mac 0000.7777.6666 ip 30.30.30.3
  mac 0000.7777.6666 ipv6 3001::1
!
```

Configure SH Nodes

Configure static MAC addresses for IPv4 (`40.40.40.4`) and IPv6 (`4000::1`) under the SH access-port (`xe27`) with VLAN ID (`103`). This setup ensures that SH advertises these static MAC addresses over the specified access-port. Repeat the same configurations for other SH nodes using different static MAC addresses for both IPv4 and IPv6.

```
!
interface xe27.103 switchport
 encapsulation dot1q 100
 load-interval 30
 access-if-evpn
  map vpn-id 203
  mac 0000.0000.0011
  mac 0000.5544.4455 ip 40.40.40.4
  mac 0000.5544.4455 ipv6 4000::1
!
```

Validation

Verify the MAC table entries on MH nodes (MH1, MH2 and MH3) and the SH nodes (SH1, SH2, SH3, and SH4). MH nodes advertise their MAC addresses using the ESI values. Additionally, verify the IP addresses associated with SH nodes for MAC advertisement.

In the `show evpn mpls mac-table` command output, the MAC entries originated from Leaf Nodes will have the `LeafFlag` field status `set`.

Note:

- MAC IPv4 or IPv6 configured under SH Leaf node access port will be advertised to the Root nodes and other Leaf nodes.
- MAC IPv4 or IPv6 configured under an MH Leaf node access port must be symmetric and will be advertised to both the Root nodes and other leaf nodes.
- MAC IPv4 or IPv6 configured under either SH or MH Root node will be advertised to both the Root nodes and the Leaf nodes.
- The Leaf-to-Leaf communication will display MAC status and tunnel status per VNI as Leaf type. The MAC will be in the discard state in the BCM shell.

```
LEAF1#show evpn mpls mac-table
=================================================================================================================================
                                                     EVPN MPLS MAC Entries
=================================================================================================================================
VNID Interface  VlanId  In-VlanId Mac-Addr       VTEP-Ip/ESI                    Type Status MAC move AccessPortDesc LeafFlag
_________________________________________________________________________________________________________________________________

203  po1.103   ----   ----       0000.7777.9999 00:00:00:43:21:12:34:00:00:00      Static Local   ------- 0 -------  set
203  po1.103   ----   ----       0000.7777.6666 00:00:00:43:21:12:34:00:00:00      Static Local  -------  0 -------  set

Total number of entries are : 8

ROOT1#show evpn mpls mac-table
================================================================================================================================
                                                     EVPN MPLS MAC Entries
```

```
=================================================================================================================
VNID Interface VlanId  In-VlanId Mac-Addr       VTEP-Ip/ESI                  Type Status  MAC move AccessPortDesc LeafFlag
_________________________________________________________________________________________________________________

203 ----      ----     ----      0000.7777.9999 00:00:00:43:21:12:34:00:00:00  Static Remote -------    0 -------  set
203 ----      ----     ----      0000.7777.6666 00:00:00:43:21:12:34:00:00:00  Static Remote  -------  0  -------  set

Total number of entries are : 8
```

Use the `show evpn mpls arp-cache` command to verify the Address Resolution Protocol (ARP) cache information on all nodes. This command displays entries that map IPv4 addresses to MAC addresses within the specified EVPN ID network.

```
LEAF1#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
203      30.30.30.3       0000.7777.6666 Static Local   ----
Total number of entries are 5

ROOT1#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  570 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
203      30.30.30.3       0000.7777.6666 Static Remote  ----
Total number of entries are 5
```

Use the `show evpn mpls nd-cache` command to verify the Neighbor Discovery (ND) cache information on all nodes. This command displays entries that map IPv6 addresses to MAC addresses within the specified EVPN ID network.

```
LEAF1#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
==============================
EVPN-ID  Ip-Addr                      Mac-Addr         Type        Age-Out Retries-Left
______________________________________________________________________________________
203      3001::1                        0000.7777.6666 Static Local     ----
Total number of entries are 4

ROOT1#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
==============================
EVPN-ID  Ip-Addr                      Mac-Addr         Type        Age-Out Retries-Left
______________________________________________________________________________________
203      3001::1                        0000.7777.6666 Static Remote    ----
Total number of entries are 4
```

Network Topology Snippet Configurations

Here are the snippet configurations for all nodes in the given network topology.

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LEAF1

```
!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn esi hold-time 90
!
evpn etree enable
!
evpn mpls multihoming enable
!
mac vrf vrf103
 rd 8.8.8.8:103
 route-target both 65535:103
!
evpn mpls vtep-ip-global 8.8.8.8
!
evpn mpls mac-ageing-time 60
!
evpn mpls id 203 etree-leaf
 host-reachability-protocol evpn-bgp vrf103
!
qos enable
!
router ldp
 router-id 8.8.8.8
 fast-reroute
 graceful-restart full
 graceful-restart timers neighbor-liveness 120
 graceful-restart timers max-recovery 120
 session-protection duration 10
 targeted-peer ipv4 9.9.9.9
  exit-targeted-peer-mode
 targeted-peer ipv4 24.24.24.24
  exit-targeted-peer-mode
 transport-address ipv4 8.8.8.8
!
router rsvp
!
interface po1
 switchport
 load-interval 30
 evpn multi-homed system-mac 0000.4321.1234
!
interface po1.103 switchport
 encapsulation dot1q 103
 load-interval 30
 access-if-evpn
  map vpn-id 203
  mac 0000.7777.9999
  mac 0000.7777.6666 ip 30.30.30.3
  mac 0000.7777.6666 ipv6 3001::1
!
interface lo
 ip address 8.8.8.8/32 secondary
```

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```
 ip router isis ISIS-IGP
 enable-ldp ipv4
!
interface xe8
 switchport
!
interface xe11
 description connected to ROOT2 int xe9
 ip address 24.1.4.25/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe20
 description connected to ROOT1 int xe20
 ip address 26.1.2.27/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe26
 channel-group 1 mode active
!
interface xe27
 speed 10g
!
interface xe27.100 switchport
 encapsulation dot1q 100
 load-interval 30
 access-if-evpn
  map vpn-id 200
  mac 0000.0000.0011
  mac 0000.5544.4455 ip 40.40.40.4
  mac 0000.5544.4455 ipv6 4000::1
!
 exit
!
router isis ISIS-IGP
 is-type level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 8.8.8.8
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0008.00
!
router bgp 65535
 neighbor 9.9.9.9 remote-as 65535
```

```
 neighbor 24.24.24.24 remote-as 65535
 neighbor 26.26.26.26 remote-as 65535
 neighbor 29.29.29.29 remote-as 65535
 neighbor 9.9.9.9 update-source lo
 neighbor 9.9.9.9 fall-over bfd
 neighbor 24.24.24.24 update-source lo
 neighbor 24.24.24.24 fall-over bfd
 neighbor 26.26.26.26 update-source lo
 neighbor 26.26.26.26 fall-over bfd
 neighbor 29.29.29.29 update-source lo
 neighbor 29.29.29.29 fall-over bfd
 !
 address-family l2vpn evpn
 neighbor 9.9.9.9 activate
 neighbor 24.24.24.24 activate
 neighbor 26.26.26.26 activate
 neighbor 29.29.29.29 activate
 exit-address-family
 !
 exit
!
rsvp-path LEAF1-ROOT2 mpls
 24.1.4.24 strict
!
rsvp-path LEAF1-ROOT1 mpls
 26.1.2.26 strict
!
rsvp-trunk LEAF1-ROOT1 ipv4
 primary fast-reroute protection facility
 primary path LEAF1-ROOT1
 to 9.9.9.9
!
rsvp-trunk LEAF1-ROOT2 ipv4
 primary fast-reroute protection facility
 primary path LEAF1-ROOT2
 to 24.24.24.24
!
```

LEAF2

```
!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn esi hold-time 90
!
evpn mpls multihoming enable
!
mac vrf vrf103
 rd 26.26.26.26:103
 route-target both 65535:103
!
evpn mpls vtep-ip-global 26.26.26.26
!
evpn mpls mac-ageing-time 60
```

```
!
evpn mpls id 203 etree-leaf
 host-reachability-protocol evpn-bgp vrf103
!
qos enable
!
router ldp
 router-id 26.26.26.26
 fast-reroute
 graceful-restart full
 graceful-restart timers neighbor-liveness 120
 graceful-restart timers max-recovery 120
 session-protection duration 10
 targeted-peer ipv4 9.9.9.9
  exit-targeted-peer-mode
 targeted-peer ipv4 24.24.24.24
  exit-targeted-peer-mode
 transport-address ipv4 26.26.26.26
!
router rsvp
!
interface po1
 switchport
 load-interval 30
 evpn multi-homed system-mac 0000.4321.1234
!
interface po1.103 switchport
 encapsulation dot1q 103
 load-interval 30
 access-if-evpn
  map vpn-id 203
!
interface lo
 ip address 26.26.26.26/32 secondary
 ip router isis ISIS-IGP
 enable-ldp ipv4
!
interface xe3
 channel-group 1 mode active
!
interface xe5
 description connected to ROOT1 int xe30
 ip address 26.1.7.27/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe6
 description connected to ROOT2 int xe6
 ip address 24.1.5.25/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
 exit
```

```
!
router isis ISIS-IGP
 is-type level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 26.26.26.26
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0026.00
!
router bgp 65535
 neighbor 8.8.8.8 remote-as 65535
 neighbor 9.9.9.9 remote-as 65535
 neighbor 24.24.24.24 remote-as 65535
 neighbor 29.29.29.29 remote-as 65535
 neighbor 8.8.8.8 update-source lo
 neighbor 8.8.8.8 fall-over bfd
 neighbor 9.9.9.9 update-source lo
 neighbor 9.9.9.9 fall-over bfd
 neighbor 24.24.24.24 update-source lo
 neighbor 24.24.24.24 fall-over bfd
 neighbor 29.29.29.29 update-source lo
 neighbor 29.29.29.29 fall-over bfd
 !
 address-family l2vpn evpn
 neighbor 8.8.8.8 activate
 neighbor 9.9.9.9 activate
 neighbor 24.24.24.24 activate
 neighbor 29.29.29.29 activate
 exit-address-family
 !
 exit
!
rsvp-path LEAF2-ROOT2 mpls
 24.1.5.24 strict
!
rsvp-path LEAF2-ROOT1 mpls
 26.1.7.26 strict
!
rsvp-trunk LEAF2-ROOT1 ipv4
 primary fast-reroute protection facility
 primary path LEAF2-ROOT1
 to 9.9.9.9
!
rsvp-trunk LEAF2-ROOT2 ipv4
 primary fast-reroute protection facility
 primary path LEAF2-ROOT2
 to 24.24.24.24
!
```

LEAF3

```
!
evpn mpls enable
!
mac vrf vrf103
 rd 29.29.29.29:103
 route-target both 65535:103
!
evpn mpls vtep-ip-global 29.29.29.29
!
evpn mpls mac-ageing-time 60
!
evpn mpls id 203 etree-leaf
 host-reachability-protocol evpn-bgp vrf103
!
qos enable
!
router ldp
 router-id 29.29.29.29
 fast-reroute
 graceful-restart full
 graceful-restart timers neighbor-liveness 120
 graceful-restart timers max-recovery 120
 session-protection duration 10
 targeted-peer ipv4 9.9.9.9
  exit-targeted-peer-mode
 targeted-peer ipv4 24.24.24.24
  exit-targeted-peer-mode
 transport-address ipv4 29.29.29.29
!
router rsvp
!
interface ge0
 static-channel-group 3
!
interface ge7
 description connected to ROOT1 int xe7
 ip address 26.1.6.27/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface lo
 ip address 29.29.29.29/32 secondary
 ip router isis ISIS-IGP
 enable-ldp ipv4
!
interface xe12
 switchport
!
interface xe12.103 switchport
 encapsulation dot1q 103
 load-interval 30
 access-if-evpn
  map vpn-id 203
```

```
!
interface xe14
 description connected to ROOT2 int xe13
 ip address 24.1.8.25/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
 exit
!
router isis ISIS-IGP
 is-type level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 29.29.29.29
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0029.00
!
router bgp 65535
 neighbor 8.8.8.8 remote-as 65535
 neighbor 9.9.9.9 remote-as 65535
 neighbor 24.24.24.24 remote-as 65535
 neighbor 26.26.26.26 remote-as 65535
 neighbor 8.8.8.8 update-source lo
 neighbor 8.8.8.8 fall-over bfd
 neighbor 9.9.9.9 update-source lo
 neighbor 9.9.9.9 fall-over bfd
 neighbor 24.24.24.24 update-source lo
 neighbor 24.24.24.24 fall-over bfd
 neighbor 26.26.26.26 update-source lo
 neighbor 26.26.26.26 fall-over bfd
 !
 address-family l2vpn evpn
 neighbor 8.8.8.8 activate
 neighbor 9.9.9.9 activate
 neighbor 24.24.24.24 activate
 neighbor 26.26.26.26 activate
 exit-address-family
 !
 exit
!
rsvp-path LEAF3-ROOT2 mpls
 24.1.8.24 strict
!
rsvp-path LEAF3-ROOT1 mpls
 26.1.6.26 strict
!
rsvp-trunk LEAF3-ROOT1 ipv4
```

```
 primary fast-reroute protection facility
 primary path LEAF3-ROOT1
 to 9.9.9.9
!
rsvp-trunk LEAF3-ROOT2 ipv4
 primary fast-reroute protection facility
 primary path LEAF3-ROOT2
 to 24.24.24.24
!
```

ROOT1

```
!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn esi hold-time 90
!
evpn mpls multihoming enable
!
mac vrf vrf103
 rd 9.9.9.9:103
 route-target both 65535:103
!
evpn mpls vtep-ip-global 9.9.9.9
!
evpn mpls mac-ageing-time 60
!
evpn mpls id 203
 host-reachability-protocol evpn-bgp vrf103
!
qos enable
!
bridge 1 protocol rstp vlan-bridge
!
router ldp
 router-id 9.9.9.9
 fast-reroute
 graceful-restart full
 graceful-restart timers neighbor-liveness 120
 graceful-restart timers max-recovery 120
 session-protection duration 10
 targeted-peer ipv4 8.8.8.8
  exit-targeted-peer-mode
 targeted-peer ipv4 26.26.26.26
  exit-targeted-peer-mode
 transport-address ipv4 9.9.9.9
!
router rsvp
!
interface po100
 switchport
 load-interval 30
 evpn multi-homed system-mac 0000.1111.2222
!
interface po100.103 switchport
```

```
 encapsulation dot1q 103
 load-interval 30
 access-if-evpn
  map vpn-id 203
!
interface lo
 ip address 9.9.9.9/32 secondary
 ip router isis ISIS-IGP
 enable-ldp ipv4
!
interface xe7
 description connected to LEAF3 int ge7
 speed 1g
 ip address 26.1.6.26/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe10
 channel-group 100 mode active
!
interface xe17.100 switchport
 description for Static mac advertize
 encapsulation dot1q 100
 load-interval 30
 access-if-evpn
  map vpn-id 200
  mac 0000.0000.0022
  mac 0000.00dc.0001 ip 10.10.10.1
  mac 0000.00dc.0001 ipv6 1001::1
!
interface xe19
 switchport
!
interface xe20
 description connected to LEAF1 int xe20
 ip address 26.1.2.26/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe30
 description connected to LEAF2 int xe5
 speed 10g
 ip address 26.1.7.26/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
 exit
!
router isis ISIS-IGP
 is-type level-1
 ignore-lsp-errors
```

```
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 9.9.9.9
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0009.00
!
router bgp 65535
 neighbor 8.8.8.8 remote-as 65535
 neighbor 24.24.24.24 remote-as 65535
 neighbor 26.26.26.26 remote-as 65535
 neighbor 29.29.29.29 remote-as 65535
 neighbor 8.8.8.8 update-source lo
 neighbor 8.8.8.8 fall-over bfd
 neighbor 24.24.24.24 update-source lo
 neighbor 24.24.24.24 fall-over bfd
 neighbor 26.26.26.26 update-source lo
 neighbor 26.26.26.26 fall-over bfd
 neighbor 29.29.29.29 update-source lo
 neighbor 29.29.29.29 fall-over bfd
 !
 address-family l2vpn evpn
 neighbor 8.8.8.8 activate
 neighbor 24.24.24.24 activate
 neighbor 26.26.26.26 activate
 neighbor 29.29.29.29 activate
 exit-address-family
 !
 exit
!
rsvp-path ROOT1-LEAF3 mpls
 26.1.6.27 strict
!
rsvp-path ROOT1-LEAF2 mpls
 26.1.7.27 strict
!
rsvp-path ROOT1-LEAF1 mpls
 26.1.2.27 strict
!
rsvp-trunk ROOT1-LEAF1 ipv4
 primary fast-reroute protection facility
 primary path ROOT1-LEAF1
 to 8.8.8.8
!
rsvp-trunk ROOT1-LEAF2 ipv4
 primary fast-reroute protection facility
 primary path ROOT11-LEAF2
 to 26.26.26.26
!
rsvp-trunk ROOT1-LEAF3 ipv4
 primary fast-reroute protection facility
```

```
 primary path ROOT1-LEAF3
 to 29.29.29.29
!
```

ROOT2

```
!
hardware-profile filter evpn-mpls-mh enable
!
evpn mpls enable
!
evpn esi hold-time 90
!
evpn mpls multihoming enable
!
mac vrf vrf103
 rd 24.24.24.24:103
 route-target both 65535:103
!
evpn mpls vtep-ip-global 24.24.24.24
!
evpn mpls mac-ageing-time 60
!
evpn mpls id 203
 host-reachability-protocol evpn-bgp vrf103
!
qos enable
!
router ldp
 router-id 24.24.24.24
 fast-reroute
 graceful-restart full
 graceful-restart timers neighbor-liveness 120
 graceful-restart timers max-recovery 120
 session-protection duration 10
 targeted-peer ipv4 8.8.8.8
  exit-targeted-peer-mode
 targeted-peer ipv4 26.26.26.26
  exit-targeted-peer-mode
 transport-address ipv4 24.24.24.24
!
router rsvp
!
interface po100
 switchport
 load-interval 30
 evpn multi-homed system-mac 0000.1111.2222
!
interface po100.103 switchport
 encapsulation dot1q 103
 load-interval 30
 access-if-evpn
  map vpn-id 203
!
interface lo
 ip address 24.24.24.24/32 secondary
 ip router isis ISIS-IGP
```

```
 enable-ldp ipv4
!
interface xe6
 description connected to LEAF2 int xe6
 speed 10g
 ip address 24.1.5.24/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe7
 switchport
!
interface xe9
 description connected to LEAF1 int xe11
 speed 10g
 ip address 24.1.4.24/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe13
 description connected to LEAF3 int xe14
 speed 10g
 ip address 24.1.8.24/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe18
 channel-group 100 mode active
!
 exit
!
router isis ISIS-IGP
 is-type level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 24.24.24.24
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0024.00
!
router bgp 65535
 neighbor 8.8.8.8 remote-as 65535
 neighbor 9.9.9.9 remote-as 65535
 neighbor 26.26.26.26 remote-as 65535
```

```
 neighbor 29.29.29.29 remote-as 65535
 neighbor 8.8.8.8 update-source lo
 neighbor 8.8.8.8 fall-over bfd
 neighbor 9.9.9.9 update-source lo
 neighbor 9.9.9.9 fall-over bfd
 neighbor 26.26.26.26 update-source lo
 neighbor 26.26.26.26 fall-over bfd
 neighbor 29.29.29.29 update-source lo
 neighbor 29.29.29.29 fall-over bfd
 !
 address-family l2vpn evpn
 neighbor 8.8.8.8 activate
 neighbor 9.9.9.9 activate
 neighbor 26.26.26.26 activate
 neighbor 29.29.29.29 activate
 exit-address-family
 !
 exit
!
rsvp-path ROOT2-LEAF1 mpls
 24.1.4.25 strict
!
rsvp-path ROOT2-LEAF2 mpls
 24.1.5.25 strict
!
rsvp-path ROOT2-LEAF3 mpls
 24.1.8.25 strict
!
rsvp-trunk ROOT2-LEAF1 ipv4
 primary fast-reroute protection facility
 primary path ROOT2-LEAF1
 to 8.8.8.8
!
rsvp-trunk ROOT2-LEAF2 ipv4
 primary fast-reroute protection facility
 primary path ROOT2-LEAF2
 to 26.26.26.26
!
rsvp-trunk ROOT2-LEAF3 ipv4
 primary fast-reroute protection facility
 primary path ROOT2-LEAF3
 to 29.29.29.29
!
```

CE SWITCH

```
!
bridge 1 protocol rstp vlan-bridge
!
vlan database
 vlan-reservation 4030-4094
 vlan 2-3010 bridge 1 state enable
!
interface po100
 switchport
 bridge-group 1
 switchport mode trunk
```

```
 switchport trunk allowed vlan all
!
interface lo
 ip address 32.32.32.32/32 secondary
!
interface xe9
 channel-group 100 mode active
!
interface xe17
 channel-group 100 mode active
!
interface xe1
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan all
!
 exit
!
```

SWITCH1

```
!
bridge 1 protocol rstp vlan-bridge
!
 vlan-reservation 4020-4062
 vlan 2-3000 bridge 1 state enable
!
interface po1
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan all
!
interface lo
 ip address 7.7.7.7/32 secondary
!
interface xe1/1
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan all
!
interface xe3/1
 channel-group 1 mode active
!
interface xe3/3
 channel-group 1 mode active
!
 exit
!
```

SWITCH2

```
!
bridge 1 protocol rstp vlan-bridge
!
```

```
vlan database
 vlan 2-3000 bridge 1 state enable
!
interface sa3
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan all
!
interface ge0
 static-channel-group 3
!
interface lo
 ip address 23.23.23.23/32 secondary
!
interface xe4
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan all
!
```

E-Tree Active-Standby Configuration

To set up an E-Tree network with Active-Standby redundancy and load balancing, follow these steps:

- Connect the Switch (P1) to the Root1, LEAF1, and LEAF2 nodes in the MPLS EVPN E-Tree Topology.
- Set up the VRF, EVPN, Port-Active, and Single-Active Redundancy configuration on Root MH and Leaf MH nodes.

For more details on Active-Standby configuration, refer to the section EVPN Active-Standby.

LEAF1

```
!
mac vrf vrf600
 rd 26.26.26.26:600
 route-target both 65535:600
!
evpn mpls id 681 etree-leaf
 host-reachability-protocol evpn-bgp vrf600
!
interface po1
 switchport
 load-interval 30
 evpn multi-homed system-mac 0000.4321.1234 load-balancing port-active
  service-carving auto
!
interface po1.681 switchport
 encapsulation dot1q 681
 load-interval 30
 access-if-evpn
  map vpn-id 681
!
interface sa1
 switchport
 load-interval 30
 evpn multi-homed esi 11:22:33:00:00:00:55:66:77 load-balancing single-active
```

```
  service-carving auto
!
interface sa1.681 switchport
 encapsulation dot1q 681
 load-interval 30
 access-if-evpn
  map vpn-id 681
!
interface xe4
 description connected to P1 int xe43
 speed 10g
 load-interval 30
 ip address 25.1.2.25/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
```

LEAF2

```
!
mac vrf vrf600
 rd 26.26.26.26:600
 route-target both 65535:600
!
evpn mpls id 681 etree-leaf
 host-reachability-protocol evpn-bgp vrf600
!
interface po1
 switchport
 load-interval 30
 evpn multi-homed system-mac 0000.4321.1234 load-balancing port-active
  service-carving auto
!
interface po1.681 switchport
 encapsulation dot1q 681
 load-interval 30
 access-if-evpn
  map vpn-id 681
!
interface sa2
 switchport
 load-interval 30
 evpn multi-homed esi 11:22:33:00:00:00:55:66:77 load-balancing single-active
  service-carving auto
!
interface sa2.681 switchport
 encapsulation dot1q 681
 load-interval 30
 access-if-evpn
  map vpn-id 681
!
interface xe21
 description connected to P1 int xe43
 speed 10g
 load-interval 30
```

```
 ip address 27.1.2.25/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
```

P1

```
!
router ldp
 router-id 6.6.6.6
 graceful-restart full
 graceful-restart timers neighbor-liveness 120
 graceful-restart timers max-recovery 120
 session-protection duration 10
 transport-address ipv4 6.6.6.6
!
interface lo
 ip address 127.0.0.1/8
 ip address 6.6.6.6/32 secondary
 ipv6 address ::1/128
 ip router isis ISIS-IGP
 enable-ldp ipv4
!
interface xe43
 description connected to LEAF1 int xe4
 speed 10g
 load-interval 30
 ip address 25.1.2.24/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe45
 description connected to ROOT1 int xe2
 speed 10g
 load-interval 30
 ip address 26.1.3.27/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
interface xe47
 description connected to LEAF2 int xe21
 speed 10g
 load-interval 30
 ip address 27.1.2.24/24
 label-switching
 ip router isis ISIS-IGP
 enable-ldp ipv4
 enable-rsvp
!
 exit
```

```
!
router isis ISIS-IGP
 is-type level-1
 authentication mode md5 level-1
 ignore-lsp-errors
 lsp-gen-interval 5
 spf-interval-exp level-1 50 2000
 metric-style wide
 mpls traffic-eng router-id 6.6.6.6
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute terminate-hold-on interval 10000
 fast-reroute per-prefix level-1 proto ipv4 all
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0006.00
!
```

Validation

To verify the status of the ESI, whether it's active or standby, use the `show evpn load-balance all` command. This command helps debug and understand if the election process is occurring correctly. For the ESI `00:00:00:43:21:12:34:00:00:00`, LEAF1 is active, and LEAF2 is on standby in port-active mode. For the ESI `00:11:22:33:00:00:00:55:66:77`, LEAF2 is active, and LEAF1 is on standby in single-active mode.

```
LEAF1#show evpn load-balance all
ESI                            AC-IF/PE     PE-IP-ADDRESS    Redundancy   Service-carving weight Revertive  AC-DF   Status
===========================================================================================================================
00:00:00:43:21:12:34:00:00:00   LOCAL      8.8.8.8          port-active    auto           0       NO         NA     ACTIVE
00:00:00:43:21:12:34:00:00:00   REMOTE     26.26.26.26      port-active    auto           0       NO         NA     STANDBY
00:11:22:33:00:00:00:55:66:77   sa1.681    8.8.8.8          single-active  auto           0       NO         NO     STANDBY

LEAF2#show evpn load-balance all
ESI                            AC-IF/PE     PE-IP-ADDRESS    Redundancy   Service-carving weight Revertive  AC-DF   Status
===========================================================================================================================
00:00:00:43:21:12:34:00:00:00   REMOTE      8.8.8.8          port-active   auto           0       NO         NA     ACTIVE
00:00:00:43:21:12:34:00:00:00   LOCAL       26.26.26.26      port-active   auto           0       NO         NA     STANDBY
00:11:22:33:00:00:00:55:66:77   sa2.681     26.26.26.26      single-active  auto          0       NO         NO     ACTIVE
```

All MAC addresses in Root and Leaf nodes will be synchronized.

```
LEAF1#show evpn mpls mac-table
==========================================================================================================================
                                                     EVPN MPLS MAC Entries
==========================================================================================================================
VNID      Interface VlanId    In-VlanId Mac-Addr       VTEP-Ip/ESI                                  Type           Status
MAC move AccessPortDesc LeafFlag
__________________________________________________________________________________________________________________________

681        po1.681   ----      ----      0000.da00.0001 00:00:00:43:21:12:34:00:00:00                Dynamic Local   ------
-    0       -------          set
681        ----      ----      ----      0000.ea00.0001 00:00:00:11:11:22:22:00:00:00                Dynamic Remote  ------
-    0       -------          ----

Total number of entries are : 2

LEAF2#show evpn mpls mac-table
==========================================================================================================================
                                                     EVPN MPLS MAC Entries
==========================================================================================================================
VNID      Interface VlanId    In-VlanId Mac-Addr       VTEP-Ip/ESI                                  Type           Status
MAC move AccessPortDesc LeafFlag
__________________________________________________________________________________________________________________________
```

```
681        ----      ----      ----      0000.da00.0001 00:00:00:43:21:12:34:00:00:00            Dynamic Remote  ------
-    0        -------          set
681        ----      ----      ----      0000.ea00.0001 00:00:00:11:11:22:22:00:00:00            Dynamic Remote  ------
-    0        -------          ----

Total number of entries are : 2

ROOT1#show evpn mpls mac-table
=========================================================================================================================
                                                    EVPN MPLS MAC Entries
=========================================================================================================================
VNID      Interface VlanId    In-VlanId Mac-Addr      VTEP-Ip/ESI                                   Type          Status
MAC move AccessPortDesc LeafFlag
_________________________________________________________________________________________________________________________

681        ----      ----      ----      0000.da00.0001 00:00:00:43:21:12:34:00:00:00            Dynamic Remote  ------
-    0        -------          set
681        po100.681 ----      ----      0000.ea00.0001 00:00:00:11:11:22:22:00:00:00            Dynamic Local   ------
-    0        -------          ----

Total number of entries are : 2
```

Implementation Examples

Here is an example scenario and a solution for implementing EVPN E-Tree.

Scenario 1: Specific traffic isolation and control measures are essential in a network of EVPN L2VPN services or instances. Within a broadcast domain, services communicating with each other may result in flooding BUM traffic to all services within the domain. Moreover, hosts are learned and advertised between different sites/services.

Use Case 1: Implementing an EVPN E-Tree solution defines the network topology with distinct Root and Leaf classifications, BUM traffic flooding can be minimized, and traffic isolation can be achieved. This ensures efficient communication between services while preventing unnecessary traffic propagation and maintaining network integrity.

Scenario 2: An Internet Service Provider (ISP) provides services to multiple subscribers and aims to facilitate communication with them. However, the ISP needs to ensure that subscribers exclusively communicate with the ISP and not among themselves.

Use Case 2: Implementing EVPN E-Tree is essential to fulfill this requirement. By categorizing ISP services as Root and subscribers as Leaf, traffic isolation can be enforced. This configuration enables the ISP to communicate with subscribers while preventing inter-subscriber communication. As a result, network security is enhanced, and the ISP maintains control over communication within its network.

E-Tree CLI Commands

The EVPN E-Tree introduces the following configuration commands in OcNOS.

evpn etree

Use this command to enable E-Tree functionality within the EVPN configuration.

Command Syntax

```
evpn etree enable
```

Parameters

None

Default

Disabled

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates how to activate E-Tree functionality for EVPN:

```
OcNOS#configure terminal
OcNOS(config)#evpn etree enable
```

Revised CLI Commands

The following is the revised command for configuring MPLS EVPN E-Tree

evpn mpls id

- The existing syntax now includes the newly added parameter for E-Tree, namely `etree-leaf`.
- The command `evpn mpls id <ID> etree-leaf` allows users to tailor MPLS EVPN behavior on a network device, indicating its participation as a leaf node in an E-Tree deployment. For more details, refer to the evpn mpls id command in the EVPN MPLS Commands chapter in the *OcNOS Multi-Protocol Label Switching Guide*.

Troubleshooting

1. When traffic, whether unicast (UC) or broadcast, is passed to the Intra Leaf site:
   - Check the sub-interface or physical interface counters to monitor traffic throughput and potential issues.
   - Verify the Leaf status of the corresponding VNI to ensure proper functionality.
   - Use packet sniffing tools to analyze packets in the egress direction for any anomalies or errors.
   - MAC entries learned via leaf access port should include the `set` keyword in the MAC table output.
2. If UC traffic is routed within inter-PE leaf sites:
   - Check the Leaf status of the VNI at both participating PE devices to confirm operational status.
   - Check if the advertised MAC is in discard or non-discard status using the `show mac table` command and `l2 show` in the BCM shell.
3. Verify if BUM traffic is transmitted between Leaf sites inter-PE:
   - Ensure that a BUM tunnels are not established between inter-PE devices.
   - Validate this by examining the Multicast ingress group, using the `show evpn mpls tunnel` command. For EVPN MPLS, confirm that BUM tunnels are not created.
4. Investigate UC traffic drops from the Root to MH Leaf PE:

- Check if MAC addresses are not installed in discard status within the MH peer's access port. This status could indicate issues with MAC learning or forwarding.

5. Evaluate traffic between Root and Leaf:
    - Confirm the establishment of both UC and BUM tunnels.
    - Ensure that unicast MAC addresses are not marked with a discard status in the MAC table.
6. Validate the exchange of routes between two BGP L2VPN peers:
    - Monitor BGP (Border Gateway Protocol) sessions to verify successful route exchange and propagation between the peers.
7. Convergence: Assess convergence by checking BFD configuration between BGP sessions.

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	**Description**
EVPN E-Tree (Ethernet VPN Ethernet-Tree)	A networking solution designed to manage communication within broadcast domains, incorporating redundancy through multi-homing in a network. It optimizes traffic routing and control, categorizing network nodes based on predefined definitions of EVPN Instances as Leaf or Root, allowing or restricting communication between them.
EVPN (Ethernet Virtual Private Network)	A Layer 2 VPN technology that extends Ethernet services across data centers and wide-area networks using BGP.
Multi-homing (MH)	The ability of a device to connect to multiple network segments simultaneously to increase network availability and redundancy.
Provider Edge (PE) Node	A device at the edge of a service provider network that connects to customer premises equipment (CE) and participates in providing services to customers.
Leaf Node	In the context of EVPN E-Tree, a network node categorized to handle communication within specific broadcast domains and may connect to Root nodes.
Root Node	A network node within EVPN E-Tree that serves as the central point of communication and handles BUM traffic distribution.
Ethernet Segment Identifier (ESI)	A unique identifier used to identify Ethernet segments within a MPLS network.

CHAPTER 5 TWAMP over EVPN Configuration

This chapter contains a complete sample TWAMP over EVPN configuration.

Two-way Active Measurement Protocol (TWAMP) is an open protocol for measuring network performance between any two devices. The TWAMP MPLS transport is implemented as part of supporting TWAMP on routers which acts as MPLS routers both in the roles of LERs as well as intermediate routers. Ocnos 6.0 also supports the end to end statistics calculation when multiple paths are available between sender and reflector with multihop support.

The user can use the link delay metrics such as average, minimum, and maximum delay, and delay variance to determine the network latency. Using link delay metrics will enable troubleshooting latency issues or apply Traffic Engineering (TE) solutions to meet Service Level Agreements (SLAs).

The TWAMP protocol is designed to do such measurements, and a basic implementation of this protocol has already been implemented in ocnos. This feature here is a TWAMP protocol in ocnos where the focus will be on accuracy and configurable advertisement of the measured data.

EVPN (based on MPLS) Supported scenarios:

In general, TWAMP over EVPN works on,

- CE-CE Overlay Only
- CE-PE Overlay Only
- PE-PE Both Under lay and over lay

Topology

Figure 5-9 displays a sample TWAMP over EVPN topology.

- CE1 and CE2 are customer edge routers
- PE1 and PE2 are IPv4 Provider Edge routers
- P1 is the router at the core of the IPv4 MPLS provider network

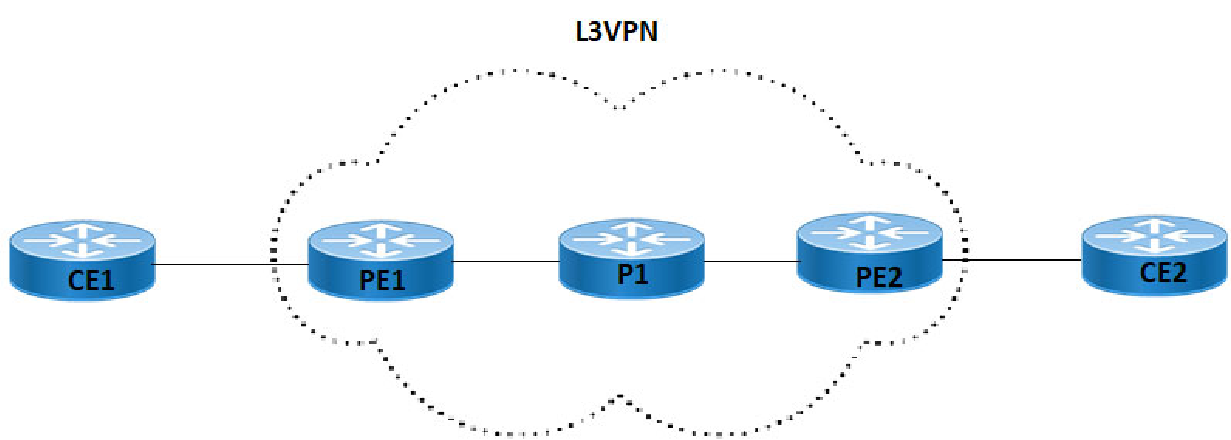

Figure 5-9: TWAMP over EVPN Topology

Configure TWAMP over EVPN for LDP

EVPN-Eline configurations

PE1

#configure terminal	Enter Configure mode.
(config)# evpn mpls enable	Enable EVPN MPLS
(config)# evpn mpls vtep-ip-global 18.18.18.18	Configuring VTEP global IP to loopback IP
(config)# mac vrf eline500	Create a new mac VRF named eline100
(config-vrf)# rd 20.20.20.20:100	Assign the route distinguisher (RD) value as 20.20.20.20:100
(config-vrf)# route-target both 111:111	Configuring import and export value as 111:111 Support: route-target export route-target import
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the configurations
9config)# evpn mpls id 500 xconnect tar-get-mpls-id 501	Configure the EVPN-VPWS identifier with source identifier 2 and target identifier 501
(con-fig-evpn-mpls)#host-reachability-protocol evpn-bgp eline500	Mapping vrf "eline500" to EVPN-VPWS identifier
(config-evpn-mpls)#commit	Commit the transaction.
(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 18.18.18.18	Configure router id as loopback address
(config-router)#transport-address ipv4 18.18.18.18	Configure ldp transport addess as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 18.18.18.18/32 sec-ondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe8	Enter Interface mode
(config-if)# ip address 10.1.1.18/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe11.500 switchport	Creating L2 sub interface of physical interface xe11
(config-if)# encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 2 Supported Encapsulation: dot1ad, dot1q, untagged, default
(config-if)# access-if-evpn	Entering Access mode for EVPN MPLS ID configuration
(config-acc-if-evpn)# map vpn-id 500	Map vpn-id 500 to interface xe11.500 (VPWS)

(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 18.18.18.18	Configure OSPF router-id
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 18.18.18.18/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# commit	Commit the configurations
(config-router)# exit	Exit from router OSPF mode
(config)# router bgp 100	Enter BGP router mode
(config-router)# bgp router-id 18.18.18.18	Configure BGP router-id
(config-router)# neighbor 8.8.8.8 remote-as 100	Configure PE2 as an iBGP4+ neighbor
(config-router)# neighbor 8.8.8.8 up-date-source lo	Update the source as loopback for iBGP peering with the remote PE2 router
(config-router)# address-family l2vpn evpn	Entering into address family mode as EVPN
(config-router-af)# neighbor 8.8.8.8 activate	Enabling EVPN Address family for neighbor
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

P1

#configure terminal	Enter Configure mode.
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 3.3.3.3	Configure router id as loopback address
(config-router)#transport-address ipv4 3.3.3.3	Configure ldp transport addess as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign IP address to Loopback interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe14	Enter Interface mode
(config-if)# ip address 10.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe15	Enter Interface mode
(config-if)# ip address 11.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface

(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 18.18.18.18	Configure OSPF router-id
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# commit	Commit the configurations
(config-router)# exit	Exit from router OSPF mode

PE2

#configure terminal	Enter Configure mode.
(config)# evpn mpls enable	Enable EVPN MPLS
(config)# evpn mpls vtep-ip-global 8.8.8.8	Configuring VTEP global IP to loopback IP
(config)# mac vrf eline500	Create a new mac VRF named eline100
(config-vrf)# rd 20.20.20.20:100	Assign the route distinguisher (RD) value as 20.20.20.20:100
(config-vrf)# route-target both 111:111	Configuring import and export value as 111:111 Support: route-target export route-target import
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the configurations
9config)# evpn mpls id 501 xconnect tar-get-mpls-id 500	Configure the EVPN-VPWS identifier with source identifier 501 and target identifier 500
(con-fig-evpn-mpls)#host-reachability-protocol evpn-bgp eline500	Mapping vrf "eline500" to EVPN-VPWS identifier
(config-evpn-mpls)#exit	Exit from evpn mpls mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 8.8.8.8/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 8.8.8.8	Configure router id as loopback address
(config-router)#transport-address ipv4 8.8.8.8	Configure ldp transport addess as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface xe24	Enter Interface mode
(config-if)# ip address 11.1.1.8/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe25	Enter Interface mode

`(config-if)# ip vrf forwarding vrf100`	Bind the interface connected to the CE1 router with VRF 100
`(config-if)# ip address 101.1.1.1/24`	Assign IP address to interface
`(config-if)#exit`	Exit interface mode
`(config)# router ospf 1`	Enter Router OSPF mode
`(config-router)# ospf router-id 8.8.8.8`	Configure OSPF router-id
`(config-router)# network 11.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`(config-router)# network 8.8.8.8/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`(config-router)#exit`	Exit from router OSPF mode
`(config)# router bgp 100`	Enter BGP router mode
`(config-router)# bgp router-id 8.8.8.8`	Configure BGP router-id
`(config-router)# neighbor 18.18.18.18 remote-as 100`	Configure PE2 as an iBGP4+ neighbor
`(config-router)# neighbor 18.18.18.18 update-source lo`	Update the source as loopback for iBGP peering with the remote PE2 router
`(config-router)# address-family l2vpn evpn`	Entering into address family mode as EVPN
`(config-router-af)# neighbor 8.8.8.8 activate`	Enabling EVPN Address family for neighbor
`(config-router-af)#exit`	Exit form address family
`(config-router)# commit`	Commit the configurations

CE1

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter loopback interface mode
`(config-if)#ip address 37.37.37.37/32 secondary`	Assign IP address to Loopback interface
`(config-if)#exit`	Exit Interface mode
`(config)#interface xe24.500`	Enter Interface mode
`(config-if)#encapsulation dot1q 500`	Setting Encapsulation to dot1q with VLAN ID 500
`(config-if)# ip address 172.16.10.1/24`	Configure IP address on the interface
`(config-if)#exit`	Exit Interface mode
`(config)# router bgp 200`	Enter BGP router mode
`(config-router)# bgp router-id 37.37.37.37`	Configure BGP router-id
`(config-router)#neighbor 100.1.1.1 remote-as 100`	Configure PE1 as an eBGP4+ neighbor
`(config-router)# address-family ipv4 unicast`	Enter address-family IPv4 unicast mode
`(config-router-af)# redistribute connected`	Redistribute the connected route under address family IPv4 unicast
`(config-router-af)# neighbor 100.1.1.1 activate`	Activate the neighbor in the IPv4 address family

`(config-router-af)#exit`	Exit form address family
`(config-router)# commit`	Commit the configurations

CE2

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter loopback interface mode
`(config-if)#ip address 2.2.2.2/32 secondary`	Assign IP address to Loopback interface
`(config-if)#exit`	Exit Interface mode
`(config)#interface xe14.500`	Enter Interface mode
`(config-if)#encapsulation dot1q 500`	Setting Encapsulation to dot1q with VLAN ID 500
`(config-if)# ip address 172.16.10.2/24`	Assign IP address to interface
`(config-if)#exit`	Exit Interface mode
`(config)# router bgp 300`	Enter BGP router mode
`(config-router)# bgp router-id 2.2.2.2`	Configure BGP router-id
`(config-router)#neighbor 101.1.1.1 remote-as 100`	Configure PE2 as an eBGP4+ neighbor
`(config-router)# address-family ipv4 unicast`	Enter address-family IPv4 unicast mode
`(config-router-af)# redistribute connected`	Redistribute the connected route under address family
`IPv4 unicast`	
`(config-router-af)# neighbor 101.1.1.1 activate`	Activate the neighbor in the IPv4 address family
`(config-router-af)#exit`	Exit form address family
`(config-router)# commit`	Commit the configurations

TWAMP Configuration on Sender (CE1)

TWAMP sender is configured to measure the delay on interface xe24.500 CE1

`#configure terminal`	Enter Configure mode.
`(config)# hardware-profile filter twamp-ipv4 enable`	Enable hardware filter for ipv4 to configure TWAMP measurement configs
`(config)#commit`	Commit the configuration
`(config)# twamp-light control`	Enable TWAMP light controller on CE1
`(config-twamp-light-con)# control-admin-state enable`	Enable TWAMP Controller admin state
`(config)# interface xe24.500`	Enter Interface Loopback mode
`(config-if)# delay-measurement dynamic twamp reflector-ip 172.16.10.2`	Configure delay measurement on interface to reflector CE2
`(config-if)#commit`	Commit the configurations
`(config-if)#end`	Return to privilege mode

TWAMP Configuration on Reflector (CE2)

Configure TWAMP Reflector as interface xe24.500 on CE2

`#configure terminal`	Enter Configure mode.
`(config)# hardware-profile filter twamp-ipv4 enable`	Enable hardware filter for ipv4 to configure TWAMP measurement configs
`(config)#commit`	Commit the configuration
`(config)# twamp-light reflector`	Enable TWAMP light Reflector on CE2
`(config-twamp-light-ref)# reflec-tor-admin-state enable`	Enable the TWAMP reflector admin state
`(config-twamp-light-ref)# reflector-name pe2 reflector-ip ipv4 172.16.10.2`	Configure TWAMP reflector IP as CE2 interface IP
`(config-twamp-light-ref)#commit`	Commit the configurations
`(config-if)#end`	Return to privilege mode

Validation

1. Verify ping from CE1 to CE2

```
PE1#ping 172.16.10.2
Press CTRL+C to exit
PING 172.16.10.2 (172.16.10.2) 56(84) bytes of data.
64 bytes from 172.16.10.2: icmp_seq=1 ttl=64 time=0.776 ms
    64 bytes from 172.16.10.2: icmp_seq=2 ttl=64 time=0.553 ms
```

2. Verify the TWAMP statistics on all the configured interfaces on CE1

```
In the below verification command, packets sent and received showing as equal. So all
the TWAMP packets received reply for all the sent packets for the delay measurement.
Showing all the Round Trip Delay and Reverse Delay timers.
```

```
PE1#sh twamp-statistics
=========================================
      TWAMP Test-Session Statistics
=========================================
  Test-Session Name         : __internal_interface_xe24.500
  Start Time                : 2023 Mar 16 00:04:37
  Elapsed time(milli sec)   : 3001
  Packets Sent              : 1
  Packets Received          : 1
  Packet Loss(%)            : 0.00
  Round Trip Delay(usec)
      Minimum               : 383
      Maximum               : 383
      Average               : 383
  Forward Delay(usec)
      Minimum               : (*)
      Maximum               : (*)
      Average               : (*)
  Reverse Delay(usec)
```

```
      Minimum              : (*)
      Maximum              : (*)
      Average              : (*)
  Round Trip Delay Variation(usec)
      Minimum              : 383
      Maximum              : 383
      Average              : 383
  Forward Delay Variation(usec)
      Minimum              : (*)
      Maximum              : (*)
      Average              : (*)
  Reverse Delay Variation(usec)
      Minimum              : (*)
      Maximum              : (*)
      Average              : (*)

(*) - Time is not in sync between Sender and Reflector
```

3. Verify the List of all interfaces that are currently participating in Delay measurement

```
PE1#sh twamp-statistics interfaces
Interface  Last Advertisement  Delay(us)   Min(us)   Max(us)   Var(us)       Loss(%)
 xe24.500                   -         0         0         0         0   Not Enabled
```

4. Verify the Detailed list of TWAMP delay measurement information on interface Loopback

```
PE1#sh twamp-statistics interfaces xe24.500
Interface name    : xe24.500
Sender IP         : 172.16.10.1
Reflector IP      : 172.16.10.2
Reflector port    : 862
DSCP value        : 0
HW Status         : HW rules installed
Last Advertised stats:
  Time: 2023-03-16 00:05:08
  Average delay          : 198
  Minimum delay          : 166
  Maximum delay          : 233
  Average delay variation: 5
  Minimum delay variation: 2
  Maximum delay variation: 10
  Packets sent           : 10
  Packets received       : 10
  Packets timeout        : 0
  Packet Loss: Not Enabled
Last Calculated stats:
  Time: 2023-03-16 00:05:08
  Average delay          : 198
  Minimum delay          : 166
  Maximum delay          : 233
  Average delay variation: 5
```

```
  Minimum delay variation: 2
  Maximum delay variation: 10
  Packets sent           : 10
  Packets received       : 10
  Packets timeout        : 0
Packet Loss : Not Enabled
```

IPv6 Provider Edge Routers (6PE) /MPLS VPN Configuration

CHAPTER 1 6PE Configuration

This chapter explains about IPv6 islands over IPv4 MPLS using IPv6 Provider Edge Routers (6PE). With this technique, IPv6 islands are connected to each other across an IPv4 backbone enabled with MPLS label stacking while MP-BGP is used to announce the IPv6 routes across these MPLS tunnels. This feature can be implemented with label-switched paths (LSPs) using the Label Distribution Protocol (LDP) or Resource Reservation Protocol (RSVP).

This feature offers the following options to the service providers:

- Connect to other IPv6 networks accessible across the MPLS core.
- Provide access to IPv6 services and resources that service provider provides.
- Provide IPv6 VPN services without going for complete overhaul of existing MPLS/IPv4 core.

The 6PE uses the existing IPv4 MPLS core infrastructure for IPv6 transport. It enables IPv6 sites to communicate with each other over an IPv4 MPLS core network using MPLS label switched paths (LSPs). This feature relies heavily on multiprotocol Border Gateway Protocol (BGP) extensions in the IPv4 network configuration on the provider edge (PE) router to exchange IPv6 reachability information (in addition to an MPLS label) for each IPv6 address prefix. Edge routers are configured as dual-stack, running both IPv4 and IPv6, and use the IPv4 mapped IPv6 address for IPv6 prefix reachability exchange.

Benefits of 6PE

6PE offers the following benefits to service providers:

- Minimal operational cost and risk - No impact on existing IPv4 and MPLS services.
- Only provider edge routers require upgrade - A 6PE router can be an existing PE router or a new one dedicated to IPv6 traffic.
- No impact on IPv6 customer edge (CE) routers - The ISP can connect to any CE router running Static, IGP or EGP.
- Production services ready - An ISP can delegate IPv6 prefixes.
- IPv6 introduction into an existing MPLS service - 6PE routers can be added at any time.

IPv6 on Provider Edge Routers

The 6PE is a technique that provides global IPv6 reachability over IPv4 MPLS. It allows one shared routing table for all other devices. 6PE allows IPv6 domains to communicate with one another over the IPv4 without an explicit tunnel setup, requiring only one IPv4 address per IPv6 domain. While implementing 6PE, the provider edge routers are upgraded to support 6PE, while the rest of the core network is not touched (IPv6 unaware).

This implementation requires no re-configuration of core routers because forwarding is based on labels rather than on the IP header itself. This provides a cost-effective strategy for deploying IPv6.The IPv6 reachability information is exchanged by PE routers using multi-protocol Border Gateway Protocol (mp-iBGP) extensions. 6PE relies on mp-iBGP extensions in the IPv4 network configuration on the PE router to exchange IPv6 reachability information in addition to an MPLS label for each IPv6 address prefix to be advertised. PE routers are configured as dual stacks, running both IPv4 and IPv6, and use the IPv4 mapped IPv6 address for IPv6 prefix reachability exchange. The next hop advertised by the PE router for 6PE prefixes is still the IPv4 address that is used for IPv4 L3 VPN routes.

The following figure illustrates the 6PE topology.

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Topology

As shown in Figure 1-10:

- CE1 and CE2 are customer edge routers
- 6PE1 and 6PE2 are IPv6 Provider Edge routers
- P is the router at the core of the IPv4 MPLS provider network

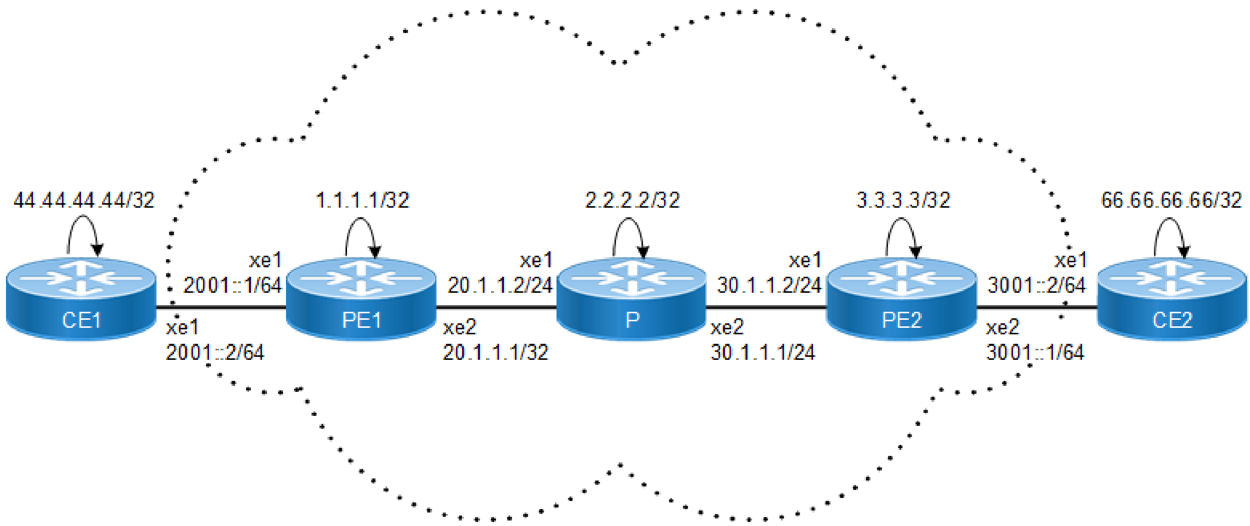

Figure 1-10: 6PE Configuration

Configuration

CE1

`#configure terminal`	Enter configure mode
`(config)#interface lo`	Enter interface mode
`(config-if)#ip address 44.44.44.44/32 secondary`	Assign the IPv4 address
`(config-if)#exit`	Exit interface mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ipv6 address 2001::2/64`	Assign the IPv6 address.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 200`	Enter router BGP mode.
`(config-router)#bgp router-id 44.44.44.44`	Assign router ID
`(config-router)#neighbor 2001::1 remote-as 100`	Configure 6PE1 as an eBGP4+ neighbor.
`(config-router)#address-family ipv6 unicast`	Enter Address-Family IPv6 unicast mode
`(config-router-af)#redistribute static`	Redistribute static routes
`(config-router-af)#neighbor 2001::1 activate`	Activate the neighbor in the IPv6 address family
`(config-router-af)#exit`	Exit address family

(config-router)#ipv6 route 2ffe::/64 xe1	Configure IPV6 static route
(config-router)#commit	Commit the transaction

CE2

#configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 66.66.66.66/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ipv6 address 3002::2/64	Assign IPv6 address
(config-if)#exit	Exit interface mode
(config)#router bgp 300	Enter BGP configure mode
(config-router)#bgp router-id 66.66.66.66	Assign router ID
(config-router)#neighbor 3002::1 remote-as 100	Configure 6PE2 as an eBGP4+ neighbor.
(config-router)#address-family ipv6 unicast	Enter Address-Family IPv6 unicast mode
(config-router-af)#redistribute static	Redistribute static routes
(config-router-af)#neighbor 3002::1 activate	Activate the neighbor in the IPv6 address family.
(config-router-af)#exit	Exit address family
(config-router)#ipv6 route 3ffe::/64 xe1	Configure IPV6 static route
(config-router)#commit	Commit the transaction

PE1

#configure terminal	Enter configure mode
(config)#interface xe1	Enter Interface mode
(config-if)#ipv6 address 2001::1/64	Assign IPv6 address
(config-if)#exit	Exit interface mode
(config)#interface lo	Enter Interface mode
(config-if)#ip address 1.1.1.1/32 secondary	Assign the IP address to loopback interface
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router ldp mode.
(config-router)#router-id 1.1.1.1	Configure router-id
(config-router)#explicit-null	Configure explicit-null.
(config-router)#transport-address ipv4 1.1.1.1	Configure transport address as loopback address
(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer
config-router-targeted-peer)#exit	Exit router targeted mode
(config-router)#exit	Exit LDP mode
(config)#interface xe2	Enter Interface mode
(config-if)#ip address 20.1.1.1/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.

(config-if)#exit	Exit interface mode
(config)#router ospf	Enter router ospf mode.
(config-router)#ospf router-id 1.1.1.1	Configure ospf router id same as loopback ip address.
(config-router)#network 1.1.1.1/32 area 0 (config-router)#network 20.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit from router ospf mode.
(config)#mpls label mode 6pe per-prefix	Change label mode to per-prefix, default is per VRF
(config)#router bgp 100	Enter BGP Configure mode.
(config-router)#bgp router-id 1.1.1.1	Configure BGP router-id
(config-router)#neighbor 3.3.3.3 remote-as 100	Configure 6PE2 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote 6PE router.
(config-router)#neighbor 2001::2 remote-as 200	Configure CE1 as eBGP peer
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 3.3.3.3 activate	Activate neighbor
(config-router-af)#exit	Exit address family mode
(config-router)#address-family ipv6 labeled-unicast	Enter IPv6 labeled-unicast Address Family mode.
(config-router-af)#neighbor 3.3.3.3 activate	Activate the 6PE neighbor
(config-router-af)#exit-address-family	Exit IPv6 LU Address Family mode.
(config-router)#address-family ipv6 unicast	Enter the IPv6 address family
(config-router-af)#neighbor 2001::2 activate	Activate CE inside IPv6 address family
(config-router-af)#redistribute connected	Redistribute the connected routes
(config-router-af)#exit	Exit IPv6 Address Family mode.
(config-router)#commit	Commit the transaction.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IP address to loopback interface
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router ldp mode.
(config-router)#router-id 2.2.2.2	Configure router-id
(config-router)#transport-address ipv4 2.2.2.2	Configure transport address as loopback address
(config-router)#exit	Exit router ldp mode.
(config)#router ospf	Enter router ospf mode.
(config-router)#ospf router-id 2.2.2.2	Configure ospf router id same as loopback ip address.
(config-router)#network 2.2.2.2/32 area 0 (config-router)#network 20.1.1.2/24 area 0 (config-router)#network 30.1.1.1/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit from router ospf mode.

(config)#interface xe2	Enter Interface mode
(config-if)#ip address 30.1.1.1/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 20.1.1.2/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode
(config)#interface xe2	Enter Interface mode
(config-if)#ipv6 address 3002::1/64	Assign IPv6 address
(config-if)#exit	Exit interface mode
(config)#interface lo	Enter Interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IP address to loopback interface
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router ldp mode.
(config-router)#router-id 3.3.3.3	Configure router-id
(config-router)#transport-address ipv4 3.3.3.3	Configure transport address as loopback address
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#explicit-null	Configure explicit-null.
(config-router)#exit	Exit LDP mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 30.1.1.2/24	Assign IPv4 address
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#exit	Exit interface mode
(config)#mpls label mode 6pe per-prefix	Change label mode to per-prefix, default is per VRF
(config)#router bgp 100	Enter router BGP mode.
(config-router)#bgp router-id 3.3.3.3	Configure BGP router id
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure 6VPE2 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 update-source lo	Update the source as loopback for iBGP peering with the remote 6VPE router.
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 1.1.1.1 activate	Activate neighbor
(config-router-af)#exit	Exit address family mode
(config-router)#neighbor 3002::2 remote-as 300	Configure CE1 as eBGP peer

`(config-router)#address-family ipv6 labeled-unicast`	Enter IPv6 labeled-unicast Address Family mode.
`(config-router-af)#neighbor 1.1.1.1 activate`	Activate the 6PE neighbor
`(config-router-af)#exit-address-family`	Exit IPv6 LU Address Family mode.
`(config-router)#address-family ipv6 unicast`	Enter the IPv6 address family
`(config-router-af)#neighbor 3002::2 activate`	Activate CE inside IPv6 address family
`(config-router-af)#redistribute connected`	Redistribute the connected routes
`(config-router-af)#exit-address-family`	Exit IPv6 Address Family mode.
`(config-router)#exit`	Exit Router mode.
`(config)#router ospf`	Enter OSPF router mode
`(config-router)#network 3.3.3.3/32 area 0`	Enable OSPF with specified area ID on interfaces with IP address that matches the specified network address
`(config-router)#network 30.1.1.0/24 area 0`	Enable OSPF with specified area ID on interfaces with IP address that matches the specified network address
`(config-router)#commit`	Commit the transaction

Validation

CE1

```
CE1#show ipv6 route
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C       ::1/128 via ::, lo, 01:10:32
C       2001::/64 via ::, xe1, 00:46:49
S       2ffe::/64 [1/0] via ::, xe1, 00:35:20
B       3002::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:02:12
B       3ffe::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:02:36
C       fe80::/64 via ::, xe3, 01:10:32
#

CE1#show ipv6 bgp summary
BGP router identifier 44.44.44.44, local AS number 200
BGP table version is 8
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V    AS    MsgRcv    MsgSen TblVer   InQ    OutQ    Up/Down   State/
PfxRcd
2001::1                4   100   80         83       8      0      0  00:01:45
3
```

```
Total number of neighbors 1

Total number of Established sessions 1
```

PE1

```
PE1#show ipv6 route
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C        ::1/128 via ::, lo, 01:17:11
C        2001::/64 via ::, xe1, 00:40:22
B        2ffe::/64 [20/0] via fe80::5054:ff:fe60:f4e5, xe1, 00:02:37
B        3002::/64 [200/0] via ::ffff:3.3.3.3, 00:03:10
B        3ffe::/64 [200/0] via ::ffff:3.3.3.3, 00:01:07
C        fe80::/64 via ::, xe2, 01:17:11

PE1#show ldp session
Peer IP Address  IF Name   My Role   State        KeepAlive     UpTime
2.2.2.2           xe2      Passive   OPERATIONAL  30            00:06:59

PE1#show bgp ipv6
BGP table version is 5, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop                    Metric    LocPrf     Weight Path
*> l 2001::/64        ::                            0        100       32768  ?
*> l 2ffe::/64        2001::2(fe80::5054:ff:fe60:f4e5)
                                                    0        100       0   200 ?
*>i  3002::/64        ::ffff:3.3.3.3                0        100       0    ?
*>i  3ffe::/64        ::ffff:3.3.3.3                0        100       0   300 ?

Total number of prefixes 4

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
```

```
   L>   2.2.2.2/32         3        3        -          -     LSP_DEFAULT  3
xe2        No    20.1.1.2
   L>   3.3.3.3/32         4        4        -          -     LSP_DEFAULT  24321
xe2        No    20.1.1.2
   L>   30.1.1.0/24        5        3        -          -     LSP_DEFAULT  3
xe2        No    20.1.1.2
   B>   3002::/64          2        2        0          Yes   LSP_DEFAULT  24960
-            No    3.3.3.3
   B>   3ffe::/64          1        1        0          Yes   LSP_DEFAULT  24961
-            No    3.3.3.3

PE1#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
2.2.2.2                  xe2       Passive   OPERATIONAL   30       00:06:59

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.1.1.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe2, out label: 24321
    Nexthop addr: 20.1.1.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 30.1.1.0/24, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.1.1.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 3002::/64, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
```

```
  Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: BGP, Stale: NO, BGP out intf: xe2, transport out
intf: xe2, out label: 24960
    Nexthop addr: 3.3.3.3        cross connect ix: 2, op code: Push and Lookup


 Primary FTN entry with FEC: 3ffe::/64, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: BGP, Stale: NO, BGP out intf: xe2, transport out
intf: xe2, out label: 24961
    Nexthop addr: 3.3.3.3        cross connect ix: 1, op code: Push and Lookup

PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                   LSP-Type
   B>   2001::/64         3          24960       Nolabel     N/A        N/A
127.0.0.1                 LSP_DEFAULT
   B>   2ffe::/64         4          24961       Nolabel     N/A        N/A
127.0.0.1                 LSP_DEFAULT
#

PE1#show ip bgp summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
3.3.3.3                4   100   42        43      1      0      0  00:08:40
0

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ipv6 bgp summary
```

```
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 5
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
2001::2                4   200   93        98      5      0      0  00:08:33
1

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ip bgp neighbors
BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 1.1.1.1, remote router ID 3.3.3.3
  BGP state = Established, up for 00:08:55
  Last read 00:00:21, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family IPv6 Labeled Unicast: advertised and received
  Received 42 messages, 0 notifications, 0 in queue
  Sent 43 messages, 1 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  0 announced prefixes

 For address family: IPv6 Labeled-Unicast
  BGP table version 6, neighbor version 6
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  2 accepted prefixes
  2 announced prefixes

 Connections established 2; dropped 1
Local host: 1.1.1.1, Local port: 34293
Foreign host: 3.3.3.3, Foreign port: 179
Nexthop: 1.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:09:51, due to Administratively Reset (Cease Notification sent)
Notification Error Message: (Cease/Administratively Reset.)
```

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```
BGP neighbor is 2001::2, remote AS 200, local AS 100, external link
  BGP version 4, local router ID 1.1.1.1, remote router ID 44.44.44.44
  BGP state = Established, up for 00:08:45
  Last read 00:00:16, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv6 Unicast: advertised and received
  Received 92 messages, 1 notifications, 0 in queue
  Sent 97 messages, 1 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv6 Unicast
  BGP table version 5, neighbor version 5
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  1 accepted prefixes
  3 announced prefixes

 Connections established 3; dropped 2
Local host: 2001::1, Local port: 179
Foreign host: 2001::2, Foreign port: 40980
Nexthop: 1.1.1.1
Nexthop global: 2001::1
Nexthop local: fe80::5054:ff:fe29:189d
BGP connection: shared network
Last Reset: 00:08:50, due to BGP Notification received
Notification Error Message: (Cease/Other Configuration Change.)
```

P1

```
P1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
3.3.3.3                   xe1       Passive   OPERATIONAL   30    00:10:11
1.1.1.1                   xe2       Active    OPERATIONAL   30    00:09:21

P1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         2         2        -           -    LSP_DEFAULT  0
xe2        No    20.1.1.1
   L>   3.3.3.3/32         1         1        -           -    LSP_DEFAULT  0
xe1        No    30.1.1.2

P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
```

```
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                    LSP-Type
   L>   3.3.3.3/32         2          24321       0           N/A        xe1
30.1.1.2                   LSP_DEFAULT
   L>   1.1.1.1/32         1          24320       0           N/A        xe2
20.1.1.1                   LSP_DEFAULT
```

PE2

```
PE2#show ipv6 route
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C       ::1/128 via ::, lo, 01:24:48
B       2001::/64 [200/0] via ::ffff:1.1.1.1, 00:11:08
B       2ffe::/64 [200/0] via ::ffff:1.1.1.1, 00:10:34
C       3002::/64 via ::, xe2, 00:24:41
B       3ffe::/64 [20/0] via fe80::5054:ff:fef6:c35d, xe2, 00:09:07
C       fe80::/64 via ::, xe3, 01:24:48

PE2#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                    LSP-Type
   B>   3002::/64          3          24960       Nolabel     N/A        N/A
127.0.0.1                  LSP_DEFAULT
   B>   3ffe::/64          4          24961       Nolabel     N/A        N/A
127.0.0.1                  LSP_DEFAULT

PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

```
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         3         2         -           -     LSP_DEFAULT  24320
xe1        No    30.1.1.1
   L>   2.2.2.2/32         1         1         -           -     LSP_DEFAULT  3
xe1        No    30.1.1.1
   L>   20.1.1.0/24        2         1         -           -     LSP_DEFAULT  3
xe1        No    30.1.1.1
   B>   2001::/64          4         3         0           Yes   LSP_DEFAULT  24960
-           No    1.1.1.1
   B>   2ffe::/64          5         4         0           Yes   LSP_DEFAULT  24961
-           No    1.1.1.1

PE2#show mpls ftn-table
 Primary FTN entry with FEC: 1.1.1.1/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe1, out label: 24320
    Nexthop addr: 30.1.1.1        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 30.1.1.1        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 20.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 30.1.1.1        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 2001::/64, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
```

```
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: BGP, Stale: NO, BGP out intf: xe1, transport out
intf: xe1, out label: 24960
    Nexthop addr: 1.1.1.1        cross connect ix: 4, op code: Push and Lookup


 Primary FTN entry with FEC: 2ffe::/64, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: BGP, Stale: NO, BGP out intf: xe1, transport out
intf: xe1, out label: 24961
    Nexthop addr: 1.1.1.1        cross connect ix: 5, op code: Push and Lookup

PE2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2                   xe1       Active    OPERATIONAL   30    00:12:01

PE2#show bgp ipv6
BGP table version is 5, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop                    Metric    LocPrf     Weight Path
*>i  2001::/64       ::ffff:1.1.1.1                 0        100       0    ?
*>i  2ffe::/64       ::ffff:1.1.1.1                 0        100       0   200 ?
*> l 3002::/64       ::                             0        100       32768  ?
*> l 3ffe::/64       3002::2(fe80::5054:ff:fef6:c35d)
                                                    0        100       0   300 ?

Total number of prefixes 4

PE2#show ip bgp neighbors
BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 3.3.3.3, remote router ID 1.1.1.1
  BGP state = Established, up for 00:11:54
  Last read 00:00:06, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family IPv6 Labeled Unicast: advertised and received
  Received 50 messages, 0 notifications, 0 in queue
  Sent 50 messages, 1 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
```

```
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  0 announced prefixes

 For address family: IPv6 Labeled-Unicast
  BGP table version 5, neighbor version 5
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  2 accepted prefixes
  2 announced prefixes

 Connections established 2; dropped 1
Local host: 3.3.3.3, Local port: 179
Foreign host: 1.1.1.1, Foreign port: 34293
Nexthop: 3.3.3.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:12:28, due to Administratively Reset (Cease Notification sent)
Notification Error Message: (Cease/Administratively Reset.)

BGP neighbor is 3002::2, remote AS 300, local AS 100, external link
  BGP version 4, local router ID 3.3.3.3, remote router ID 66.66.66.66
  BGP state = Established, up for 00:10:17
  Last read 00:00:25, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv6 Unicast: advertised and received
  Received 61 messages, 2 notifications, 0 in queue
  Sent 68 messages, 2 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv6 Unicast
  BGP table version 5, neighbor version 5
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  1 accepted prefixes
  3 announced prefixes

 Connections established 3; dropped 2
Local host: 3002::1, Local port: 52758
Foreign host: 3002::2, Foreign port: 179
Nexthop: 3.3.3.3
Nexthop global: 3002::1
Nexthop local: fe80::5054:ff:fe2b:8d4f
BGP connection: shared network
Last Reset: 00:10:22, due to BGP Notification received
```

```
Notification Error Message: (Cease/Other Configuration Change.)

PE2#show ip bgp summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
1.1.1.1                4   100   50        52      1      0      0  00:12:06
0

Total number of neighbors 1

Total number of Established sessions 1

PE2#show ipv6 bgp summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 5
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
3002::2                4   300   64        70      5      0      0  00:10:31
1

Total number of neighbors 1

Total number of Established sessions 1
```

CE2

```
CE2#show ipv6 bgp summary
BGP router identifier 66.66.66.66, local AS number 300
BGP table version is 9
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
3002::1                4   100   70        67      9      0      0  00:11:35
3

Total number of neighbors 1

Total number of Established sessions 1

CE2#show ipv6 route
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
```

```
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C       ::1/128 via ::, lo, 01:26:48
B       2001::/64 [20/0] via fe80::5054:ff:fe2b:8d4f, xe2, 00:11:43
B       2ffe::/64 [20/0] via fe80::5054:ff:fe2b:8d4f, xe2, 00:11:43
C       3002::/64 via ::, xe2, 00:24:47
S       3ffe::/64 [1/0] via ::, xe2, 00:24:05
C       fe80::/64 via ::, xe2, 01:26:48
```

CHAPTER 2 6VPE Configuration

This chapter explains how 6VPE (IPv6 on VPN Provider Edge Routers) can interconnect IPv6 islands over an MPLS-enabled IPv4 cloud. 6VPE enables IPv6 sites to communicate with each other over an MPLS/IPv4 core network using MPLS LSPs. The 6VPE routers exchange IPv6 reachability information over the core using Multi-Protocol Border Gateway Protocol (MP-BGP) over IPv4.

Topology

As shown in Figure 2-11:

- CE1 and CE2 are customer edge routers
- 6VPE1 and 6VPE2 are IPv6 Provider Edge routers
- P is the router at the core of the IPv4 MPLS provider network.

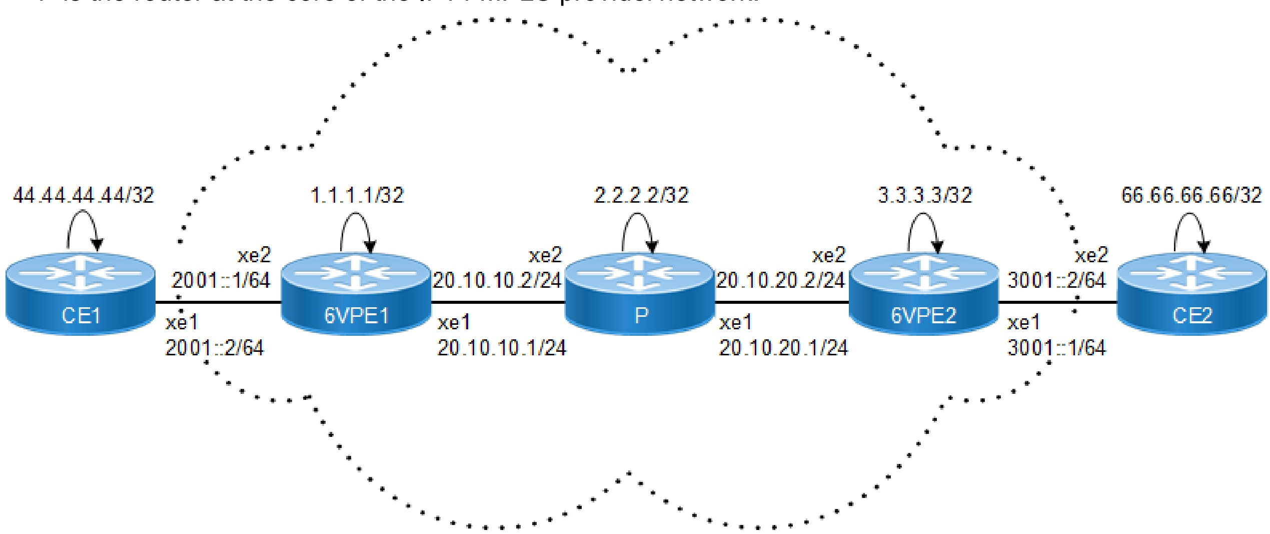

Figure 2-11: 6VPE Configuration

Configuration

CE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode
`(config-if)#ip address 44.44.44.44/32 secondary`	Assign the IPv4 address
`(config-if)#exit`	Exit interface mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ipv6 address 2001::2/64`	Assign the IPv6 address.
`(config-if)#exit`	Exit interface mode.
`(config)#ipv6 route 2ffe::/64 xe1`	Advertise IPv6 static route.
`(config)#router bgp 200`	Enter BGP router mode.

(config-router)#bgp router-id 44.44.44.44	Configure bgp router-id
(config-router)#neighbor 2001::1 remote-as 100	Configure 6VPE1 as an eBGP4+ neighbor.
(config-router)#address-family ipv6 unicast	Enter address-family IPv6 unicast mode.
(config-router-af)#neighbor 2001::1 activate	Activate the neighbor in the IPv6 address family.
(config-router-af)#redistribute connected	Redistribute the connected route under address family IPv6 unicast.
(config-router-af)#redistribute static	Redistribute static routes.
(config-router-af)#commit	Commit the transaction.

CE2

#configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 66.66.66.66/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode.
(config-if)#ipv6 address 3001::2/64	Assign the IPv6 address.
(config-if)#exit	Exit interface mode.
(config)#ipv6 route 3ffe::/64 xe1	Configure IPV6 static route
(config)#router bgp 300	Enter BGP router mode.
(config-router)#bgp router-id 66.66.66.66	Configure BGP router-id
(config-router)#neighbor 3001::1 remote-as 100	Configure 6VPE1 as an eBGP4+ neighbor.
(config-router)#address-family ipv6 unicast	Enter address-family IPv6 unicast mode.
(config-router-af)#neighbor 3001::1 activate	Activate the neighbor in the IPv6 address family.
(config-router-af)#redistribute connected	Redistribute the connected route under address family IPv6 unicast.
(config-router-af)#redistribute static	Redistribute static routes.
(config-router-af)#commit	Commit the transaction.

PE1

#configure terminal	Enter configure mode.
(config)#ip vrf IPI	Create a new VRF named IPI.
(config-vrf)#rd 1:100	Assign the route distinguisher (RD) value as 1:100.
(config-vrf)#route-target both 100:200	Import routes between route target (RT) ext-communities 100 and 200.
(config-vrf)#router-id 77.77.77.77	Configure router-id for VRF
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip vrf forwarding IPI	Bind the interface connected to the CE router with VRF IPI.
(config-if)#ipv6 address 2001::1/64	Assign the IPv6 address.

`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 100`	Enter BGP router mode.
`(config-router)#bgp router-id 1.1.1.1`	Configure BGP router-id
`(config-router)#neighbor 3.3.3.3 remote-as 100`	Configure 6VPE2 as an iBGP peer.
`(config-router)#neighbor 3.3.3.3 update-source lo`	Update the source as loopback for iBGP peering with the remote 6VPE router.
`(config-router)#address-family ipv4 unicast`	Enter address family mode
`(config-router-af)#neighbor 3.3.3.3 activate`	Activate the neighbor
`(config-router-af)#exit-address-family`	Exit address family mode
`(config-router)#address-family vpnv6 unicast`	Enter VPNv6 address family mode.
`(config-router-af)#neighbor 3.3.3.3 activate`	Activate the 6VPE neighbor so that it can accept VPN IPv6 routes.
`(config-router-af)#exit-address-family`	Exit VPNv6 address family mode.
`(config-router)#address-family ipv6 vrf IPI`	Enter the IPv6 address family for VRF IPI.
`(config-router-af)#neighbor 2001::2 remote-as 200`	Activate CE inside IPv6 address family for vrf IPI.
`(config-router-af)#neighbor 2001::2 activate`	Activate the 6VPE neighbor so that it can accept VPN IPv6 routes.
`(config-router-af)#redistribute connected`	Redistribute the connected route under address family IPv6 for VRF IPI.
`(config-router-af)#exit-address-family`	Exit IPv6 Address Family mode.
`(config-router)#exit`	Exit router mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/32 secondary`	Assign the IP address to loopback interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router LDP mode.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`(config-router)#transport-address ipv4 1.1.1.1`	Configure transport address as loopback address.
`(config-router)#targeted-peer ipv4 3.3.3.3`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router LDP mode.
`(config)#router rsvp`	Enter RSVP router mode.
`(config-router)#exit`	Exit router mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-rsvp`	Enable RSVP in interface.
`(config-if)#enable-ldp ipv4`	Enable LDP in interface.
`(config-if)#ip address 20.10.10.1/24`	Assign IP address to interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Enter OSPF router mode.
`(config-router)#ospf router-id 1.1.1.1`	Configure OSPF router id same as loopback ip address.
`(config-router)#network 1.1.1.1/32 area 0` `(config-router)#network 20.10.10.1/24 area 0`	Define the network on which OSPF runs and associate area id.

(config-router)#exit	Exit OSPF router mode.
(config)#rsvp-trunk toPE2	Enter the trunk mode for RSVP.
(config-trunk)#to 3.3.3.3	Specify IPv4 Egress for the LSP.
(config-trunk)#commit	Commit the transaction.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IP address to loopback interface.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2	Configure transport address as loopback address.
(config-router)#exit	Exit router mode.
(config)#router rsvp	Enter RSVP router mode.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-rsvp	Enable RSVP in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#ip address 20.10.10.2/24	Assign IP address to interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-rsvp	Enable RSVP in interface.
(config-if)#enable-ldp ipv4	Enable ldp in interface.
(config-if)#ip address 20.10.20.1/24	Assign IP address to interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Enter OSPF router mode.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback ip address.
(config-router)#network 2.2.2.2/32 area 0 (config-router)#network 20.10.20.1/24 area 0 (config-router)#network 20.10.10.2/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#ip vrf IPI	Create a new VRF named IPI.
(config-vrf)#rd 1:101	Assign the route distinguisher (RD) value as 1:101.

(config-vrf)#route-target both 100:200	Import routes between route target (RT) ext-communities 100 and 200.
(config-vrf)#router-id 55.55.55.55	Configure Router-id for VRF
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip vrf forwarding IPI	Bind the interface connected to the CE router with VRF IPI.
(config-if)#ipv6 address 3001::1/64	Assign the IPv6 address.
(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Enter BGP router mode.
(config-router)#bgp router-id 3.3.3.3	Configure BGP router-id
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure 6VPE2 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 update-source lo	Update the source as loopback for iBGP peering with the remote 6VPE router.
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 1.1.1.1 activate	Activate the neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family vpnv6 unicast	Enter VPNv6 address family mode.
(config-router-af)#neighbor 1.1.1.1 activate	Activate the 6VPE neighbor so that it can accept VPN IPv6 routes.
(config-router-af)#exit-address-family	Exit VPNv6 address family mode.
(config-router)#address-family ipv6 vrf IPI	Enter the IPv6 address family for VRF IPI.
(config-router-af)#neighbor 3001::2 remote-as 300	Activate CE inside IPv6 address family for vrf IPI.
(config-router-af)#neighbor 3001::2 activate	Activate the neighbor
(config-router-af)#redistribute connected	Redistribute the connected route under address family IPv6 for VRF IPI.
(config-router-af)#exit-address-family	Exit IPv6 Address Family mode.
(config-router)#exit	Exit router mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IP address to loopback interface.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3	Configure transport address as loopback address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#router rsvp	Enter RSVP router mode.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface

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(config-if)#enable-rsvp	Enable RSVP in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#ip address 20.10.20.2/24	Assign IP address to interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Enter OSPF router mode.
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router id same as loopback ip address.
(config-router)#network 3.3.3.3/32 area 0 (config-router)#network 20.10.20.2/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#rsvp-trunk toPE1	Enter the trunk mode for RSVP.
(config-trunk)#to 1.1.1.1	Specify IPv4 Egress for the LSP.
(config-trunk)#commit	Commit the transaction.

Validation

CE1

```
CE1#show ipv6 route
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C       ::1/128 via ::, lo, 01:38:28
C       2001::/64 via ::, xe1, 01:20:30
S       2ffe::/64 [1/0] via ::, xe1, 00:01:27
B       3001::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:06:40
B       3ffe::/64 [20/0] via fe80::5054:ff:fe29:189d, xe1, 00:02:24
C       fe80::/64 via ::, xe3, 01:38:28

CE1#show ipv6 bgp summary vrf all
BGP router identifier 44.44.44.44, local AS number 200
BGP table version is 4
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
2001::1                4   100 1167      1522      4      0      0  00:13:23
3

Total number of neighbors 1
```

```
Total number of Established sessions 1
```

PE1

```
PE1#show ipv6 route vrf IPI
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, D- DHCP, R - RIP,
       O - OSPF, IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, i - IS-IS, B - BGP,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "IPI"
C       2001::/64 via ::, xe1, 01:12:03
B       2ffe::/64 [20/0] via fe80::5054:ff:fe60:f4e5, xe1, 00:02:05
B       3001::/64 [200/0] via ::ffff:3.3.3.3, 00:08:02
B       3ffe::/64 [200/0] via ::ffff:3.3.3.3, 00:03:33
C       fe80::/64 via ::, xe1, 01:12:32

PE1#show ip bgp summary vrf all
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
1.1.1.1                  4   100   78         84       1      0      0  00:32:15         0

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ipv6 bgp summary vrf all
BGP router identifier 55.55.55.55, local AS number 100
BGP VRF IPI Route Distinguisher: 1:101
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
3001::2                4   200   79        81      1      0      0  00:32:15
2

Total number of neighbors 1

Total number of Established sessions 1

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
```

```
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -           -    LSP_DEFAULT  3
xe2        No    20.10.10.2
R(t)>   3.3.3.3/32         4         4         5001        Yes   LSP_DEFAULT  24320
xe2        No    20.10.10.2
   L    3.3.3.3/32         3         2         -           -    LSP_DEFAULT  24960
xe2        No    20.10.10.2
   L>   20.10.20.0/24      2         1         -           -    LSP_DEFAULT  3
xe2        No    20.10.10.2

PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Type    LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
3.3.3.3         1.1.1.1         PRI     toPE2-Primary                      UP    00:08:44
1 1 SE     -        24320     DEFAULT
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Type    LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
1.1.1.1         3.3.3.3         PRI     toPE1-Primary                      UP    00:08:39
1 1 SE     24960    -         ELSP_CON
Total 1 displayed, Up 1, Down 0.

PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                   LSP-Type
   B>   IPI               2          25600      Nolabel     N/A       IPI             N/
A                        LSP_DEFAULT
LT
   R>   3.3.3.3/32         2          24320      Nolabel     N/A       N/A
127.0.0.1                 ELSP_CONF
IG
```

```
PE1#show mpls vrf-table
Output for IPv6 VRF table with id: 2
 Primary FTN entry with FEC: 3001::/64, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
  Transport Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 0, Description: N/
A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe2, transport out
intf: xe2, out label: 24320
    Nexthop addr: 3.3.3.3        cross connect ix: 5, op code: Push and Lookup



 Primary FTN entry with FEC: 3ffe::/64, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
  Transport Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 0, Description: N/
A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe2, transport out
intf: xe2, out label: 24320
    Nexthop addr: 3.3.3.3        cross connect ix: 5, op code: Push and Lookup

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.10.10.2        cross connect ix: 1, op code: Push



 Primary FTN entry with FEC: 3.3.3.3/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
  Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 2, Description: toPE2,
Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4
      Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: RSVP, Stale: NO, out intf: xe2, out label: 24320
    Nexthop addr: 20.10.10.2        cross connect ix: 4, op code: Push



 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
```

```
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Down
       Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe2, out label: 24960
    Nexthop addr: 20.10.10.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 20.10.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.10.10.2        cross connect ix: 1, op code: Push



PE1#show ip bgp vpnv6 all
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - 
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

     Network          Next Hop                   Metric    LocPrf      Weight       Path
Route Distinguisher: 1:100 (Default for VRF IPI)
*> l 2001::/64        ::                            0        100        32768  ?
*    2001::/64        2001::2(fe80::5054:ff:fe60:f4e5)
                                                    0        100        0   200 ?
*> l 2ffe::/64        2001::2(fe80::5054:ff:fe60:f4e5)
                                                    0        100        0   200 ?
*>i  3001::/64        ::ffff:3.3.3.3                0        100        0    ?
*>i  3ffe::/64        ::ffff:3.3.3.3                0        100        0   300 ?
 Announced routes count = 3
 Accepted routes count = 2
Route Distinguisher: 1:101
*>i  3001::/64        ::ffff:3.3.3.3                0        100        0    ?
*>i  3ffe::/64        ::ffff:3.3.3.3                0        100        0   300 ?
 Announced routes count = 0
 Accepted routes count = 2

PE1#show ip bgp neighbors
BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 1.1.1.1, remote router ID 3.3.3.3
  BGP state = Established, up for 00:09:55
  Last read 00:00:21, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
```

```
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family VPNv6 Unicast: advertised and received
  Received 27 messages, 0 notifications, 0 in queue
  Sent 27 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  0 announced prefixes

 For address family: VPNv6 Unicast
  BGP table version 3, neighbor version 3
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  2 accepted prefixes
  2 announced prefixes

 Connections established 1; dropped 0
Local host: 1.1.1.1, Local port: 33537
Foreign host: 3.3.3.3, Foreign port: 179
Nexthop: 1.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

BGP neighbor is 2001::2, vrf IPI, remote AS 200, local AS 100, external link
  BGP version 4, local router ID 77.77.77.77, remote router ID 44.44.44.44
  BGP state = Established, up for 00:16:19
  Last read 00:00:10, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv6 Unicast: advertised and received
  Received 42 messages, 0 notifications, 0 in queue
  Sent 42 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv6 Unicast
  BGP table version 1, neighbor version 1
  Index 0, Offset 0, Mask 0x1
  Community attribute sent to this neighbor (standard)
  2 accepted prefixes
  3 announced prefixes

 Connections established 1; dropped 0
Local host: 2001::1, Local port: 34776
```

```
Foreign host: 2001::2, Foreign port: 179
Nexthop: 77.77.77.77
Nexthop global: 2001::1
Nexthop local: fe80::5054:ff:fe29:189d
BGP connection: shared network
```

P1

```
P1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Tunnel-id   Pri   LSP-Type        Out-Label    Out-
Intf       Nexthop
  L>    1.1.1.1/32         1       0          Yes   LSP_DEFAULT    3           xe2
20.10.10.1
  L>    3.3.3.3/32         2       0          Yes   LSP_DEFAULT    3           xe1
20.10.20.2

P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       U - unknown

Code    FEC/VRF          ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf
Nexthop                LSP-Type
   R>   1.1.1.1/32         2          24321       24960       N/A        xe1
20.10.10.1            ELSP_CONFIG
   R>   3.3.3.3/32         1          24320       24960       N/A        xe2
20.10.20.2            ELSP_CONFIG
   L>   1.1.1.1/32         4          24961       3           N/A        xe1
20.10.10.1            LSP_DEFAULT
   L>   3.3.3.3/32         5          24960       3           N/A        xe2
20.10.20.2            LSP_DEFAULT

P1#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
1.1.1.1          1   Full/Backup      00:00:31    20.10.10.1      xe1                0
3.3.3.3          1   Full/DR          00:00:32    20.10.20.2      xe2                0
```

PE2

```
PE2#show ipv6 route vrf IPI
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
```

```
       IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, I - IS-IS, B - BGP
Timers: Uptime

IP Route Table for VRF "IPI"
C      ::1/128 via ::, lo.IPI, 00:24:23
C      3001::/64 via ::, xe1, 00:24:22
B      3ffe::/64 [20/0] via fe80::3617:ebff:fe0e:1201, xe1, 00:05:28
C      fe80::/64 via ::, xe1, 00:24:22

PE2#show ip bgp summary vrf all
BGP router identifier 55.55.55.55, local AS number 100
BGP VRF IPI Route Distinguisher: 1:100
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
3001::2                4   300  116       181      1     0      0  00:22:05
0

Total number of neighbors 1

Total number of Established sessions 1
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
1.1.1.1                4   100   65        66      1     0      0  00:26:21
0

Total number of neighbors 1

Total number of Established sessions 1

PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Tunnel-id   Pri   LSP-Type        Out-Label    Out-
Intf       Nexthop
R(t)>   1.1.1.1/32        1       5001       Yes   LSP_DEFAULT    24321       xe2
20.10.20.1
  L    1.1.1.1/32        2       0          Yes   LSP_DEFAULT    24961       xe2
20.10.20.1
```

```
   L>    2.2.2.2/32         3       0          Yes   LSP_DEFAULT    3          xe2
20.10.20.1
   L>    20.10.10.0/24      4       0          Yes   LSP_DEFAULT    3          xe2
20.10.20.1

PE2#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes

Ingress RSVP:
To              From            Type  LSPName                         State Uptime    Rt
Style  Labelin  Labelout  DSType
1.1.1.1         3.3.3.3         PRI   toPE1-Primary                     UP    00:23:21  1
1 SE     -        24321     DEFAULT
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Type  LSPName                         State Uptime    Rt
Style  Labelin  Labelout  DSType
3.3.3.3         1.1.1.1         PRI   toPE2-Primary                     UP    00:23:33  1
1 SE     24960    -         ELSP_CON
Total 1 displayed, Up 1, Down 0.

PE2#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       U - unknown

Code    FEC/VRF          ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf
Nexthop                LSP-Type
   B>   3ffe::/64         3           24321       N/A         N/A        xe1
fe80::3617:ebff:fe0e:1201  LSP_DEFAULT
  B>  3001::/64       2        24320     N/A       N/A      xe1       ::
LSP_DEFAULT
   R>   3.3.3.3/32        1           24960       N/A         N/A        N/A
127.0.0.1             ELSP_CONFIG

PE2#show ip bgp neighbors
BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 3.3.3.3, remote router ID 1.1.1.1
  BGP state = Established, up for 00:23:39
  Last read 00:00:27, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family VPNv6 Unicast: advertised and received
  Received 58 messages, 0 notifications, 0 in queue
  Sent 60 messages, 0 notifications, 0 in queue
```

```
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  0 announced prefixes

 For address family: VPNv6 Unicast
  BGP table version 4, neighbor version 4
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  2 accepted prefixes
  2 announced prefixes

 Connections established 1; dropped 0
Local host: 3.3.3.3, Local port: 37145
Foreign host: 1.1.1.1, Foreign port: 179
Nexthop: 3.3.3.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

BGP neighbor is 3001::2, vrf IPI, remote AS 300, local AS 100, external link
  BGP version 4, local router ID 55.55.55.55, remote router ID 66.66.66.66
  BGP state = Established, up for 00:19:23
  Last read 00:00:05, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family IPv6 Unicast: advertised and received
  Received 110 messages, 0 notifications, 0 in queue
  Sent 113 messages, 62 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (standard)
  0 accepted prefixes
  0 announced prefixes

 For address family: IPv6 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (standard)
  2 accepted prefixes
  3 announced prefixes
```

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```
 Connections established 1; dropped 0
Local host: 3001::1, Local port: 179
Foreign host: 3001::2, Foreign port: 58741
Nexthop: 55.55.55.55
Nexthop global: 3001::1
Nexthop local: fe80::da9e:f3ff:fec9:65a1
BGP connection: shared network
Last Reset: 00:19:28, due to OPEN Message Error (Notification sent)
Notification Error Message: (OPEN Message Error/Bad BGP Identifier.)

PE2#show ip bgp vpnv6 all
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal, l -
labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:100 (Default for VRF IPI)
*>i  2001::/64       ::ffff:101:101                      0        100          0
?
*>i  2ffe::/64       ::ffff:101:101                      0        100          0
200 ?
*> l 3001::/64        ::                     0         100           32768    ?
*    3001::/64        3001::2(fe80::3617:ebff:fe0e:1201)
                                           0         100           0       300 ?
*> l 3ffe::/64        3001::2(fe80::3617:ebff:fe0e:1201)
                                           0         100           0       300 ?
 Announced routes count = 3
 Accepted routes count = 2
Route Distinguisher: 1:100
*>i  2001::/64       ::ffff:101:101                      0        100          0
?
*>i  2ffe::/64       ::ffff:101:101                      0        100          0
200 ?
 Announced routes count = 0
 Accepted routes count = 2

PE2#show mpls ftn-table
 Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active
  Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
  Tunnel id: 5001,   Protected LSP id: 2201, QoS Resource id: 2, Description: toPE1
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: RSVP, out intf: xe1, out label: 24321
    Nexthop addr: 20.10.20.1        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 1.1.1.1/32, id: 2, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
```

```
  Tunnel id: 0,   Protected LSP id: 0, Description: N/A
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Down
       Out-segment with ix: 4, owner: LDP, out intf: xe1, out label: 24961
    Nexthop addr: 20.10.20.1        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0,   Protected LSP id: 0, Description: N/A
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, out intf: xe1, out label: 3
    Nexthop addr: 20.10.20.1        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 20.10.10.0/24, id: 4, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0,   Protected LSP id: 0, Description: N/A
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, out intf: xe1, out label: 3
    Nexthop addr: 20.10.20.1        cross connect ix: 6, op code: Push


PE2#show mpls vrf-table
Output for IPv6 VRF table with id: 2
 Primary FTN entry with FEC: 2001::/64, id: 1, row status: Active
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
  Tunnel id: 5001,   Protected LSP id: 2201, QoS Resource id: 0, Description: N/A
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: BGP, out intf: N/A, out label: 24320
    Nexthop addr: 1.1.1.1        cross connect ix: 3, op code: Push and Lookup


 Primary FTN entry with FEC: 2ffe::/64, id: 2, row status: Active
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming
DSCP: none
  Tunnel id: 5001,   Protected LSP id: 2201, QoS Resource id: 0, Description: N/A
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 6
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: BGP, out intf: N/A, out label: 24321
    Nexthop addr: 1.1.1.1        cross connect ix: 7, op code: Push and Lookup
```

CE2

```
CE2#show ipv6 route
IPv6 Routing Table
```

```
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
       IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, E - EVPN  N1 - OSPF NSSA external type 1,
       N2 - OSPF NSSA external type 2, I - IS-IS, B - BGP
Timers: Uptime

IP Route Table for VRF "default"
C       ::1/128 via ::, lo, 00:37:26
B       2001::/64 [20/0] via fe80::da9e:f3ff:fec9:65a1, xe2, 00:20:44
B       2ffe::/64 [20/0] via fe80::da9e:f3ff:fec9:65a1, xe2, 00:09:52
C       3001::/64 via ::, xe2, 00:27:07
S       3ffe::/64 [1/0] via ::, xe2, 00:07:31
C       fe80::/64 via ::, xe2, 00:37:26

CE2#show ip bgp summary vrf all
BGP router identifier 66.66.66.66, local AS number 300
BGP table version is 1
3 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd
3001::1                4   100  178       176      1      0      0  00:20:51
0

Total number of neighbors 1

Total number of Established sessions 1
```

Multi-Protocol Label Switching Configuration

CHAPTER 1 Understanding Label Space

This chapter contains configurations for Label Space. It also provides an overview of Label Space concepts.

Overview

The Label space refers to the scope of labels in a given LSR. It determines assignment and distribution of labels to a given peer. During data flow, it decides the key for looking up MPLS table and takes appropriate action based on the entry.

OcNOS supports *per-platform* label space, where a label must be unique for the entire platform. A label is interpreted the same way at all the interfaces. The FIB entry in the router does not contain incoming interface-related information. Thus the incoming traffic will be matched only with the label.

Topology

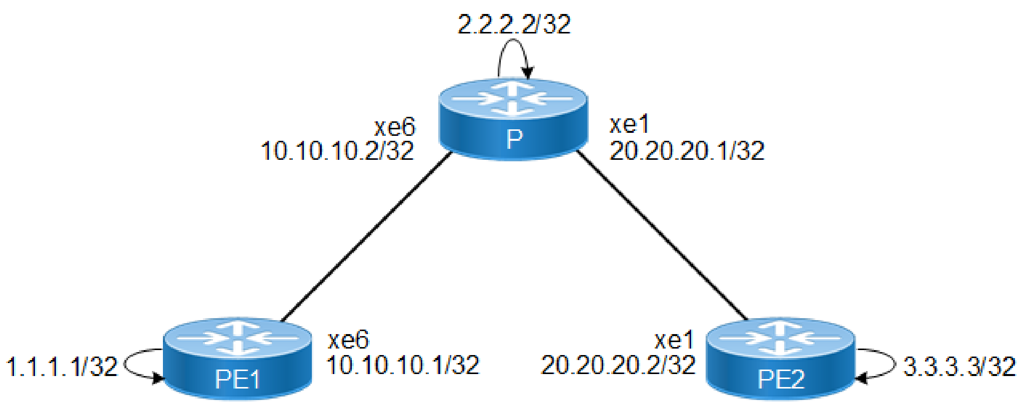

Figure 1-12: LDP Topology

PE1

`PE1#configure terminal`	Enter configure mode
`PE1(config)#interface lo`	Enter interface mode.
`PE1(config-if)#ip address 1.1.1.1/32 secondary`	Configure IP address for the loopback address
`PE1(config-if)#exit`	Exit interface mode
`PE1(config)#interface xe6`	Specify the interface `(xe6)` to be configured
`PE1(config-if)#ip address 10.10.10.1/24`	Configure IP address for the interface
`PE1(config-if)#no shutdown`	Administratively bringing up the interface
`PE1(config-if)#exit`	Exit interface mode
`PE1(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`PE1(config-router)#ospf router-id 1.1.1.1`	Configure OSPF router ID same as loopback IP address
`PE1(config-router)#network 10.10.10.0/24 area 0` `PE1(config-router)#network 1.1.1.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface

`PE1(config-router)#exit`	Exit configure mode
`PE1(config)#router ldp`	Enter router mode for LDP
`PE1(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`PE1(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`PE1(config-router)# targeted-peer ipv4 3.3.3.3`	Configure targeted peer.
`PE1(config-router-targeted-peer)#exit`	Exit from router target peer and LDP mode
`PE1(config-if)#exit`	Exit interface mode
`PE1(config)#interface xe6`	Specify the interface (xe6)to be configured
`PE1(config-if)#label-switching`	Enabling label switching capability on router
`PE1(config-if)#enable-ldp ipv4`	Enabling ldp on interface
`PE1(config-if)#commit`	Commit the transaction.

P

`P#configure terminal`	Enter configure mode.
`P(config)#interface lo`	Enter interface mode.
`P(config-if)#ip address 2.2.2.2/32 secondary`	Configure IP address for the loopback address
`P(config-if)#exit`	Exit interface mode
`P(config)#interface xe6`	Specify the interface `(xe6)` to be configured
`P(config-if)#ip address 10.10.10.2/24`	Configure IP address for the interface
`P(config-if)#no shutdown`	Administratively bringing up the interface
`P(config)#interface xe1`	Specify the interface `(xe1)` to be configured
`P(config-if)#ip address 20.20.20.1/24`	Configure IP address for the interface
`P(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`P(config-router)#ospf router-id 2.2.2.2`	Configure OSPF router ID same as loopback IP address

`P(config-router)#network 10.10.10.0/24 area 0`
`P(config-router)#network 20.20.20.0/24 area 0`
`P(config-router)#network 2.2.2.2/32 area 0`
	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface

`P(config-router)#exit`	Exit router mode
`P(config)#router ldp`	Enter router mode for LDP
`P(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2
`P(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`P(config-router)#exit`	Exit router mode for LDP

`P(config)#mpls min-label-value 1000 max-label-value 50000 label-space 0`	Configure the minimum label value and maximum label value to be used by Platform label space (Label space 0)
`P(config)#interface xe6`	Specify the interface (xe6)to be configured
`P(config-if)#label-switching`	Enabling label switching capability on router
`P(config-if)#enable-ldp ipv4`	Enabling ldp on interface
`P(config-if)#exit`	Exit interface mode
`P(config)#interface xe1`	Specify the interface (xe1) to be configured
`P(config-if)#label-switching`	Enabling label switching capability on router
`P(config-if)#enable-ldp ipv4`	Enabling ldp on interface
`P(config-if)#commit`	Commit the transaction.

PE2

`PE2#configure terminal`	Enter configure mode.
`PE2(config)#interface lo`	Enter interface mode.
`PE2(config-if)#ip address 3.3.3.3/32 secondary`	Configure IP address for the loopback address
`PE2(config-if)#exit`	Exit interface mode
`PE2(config)#interface xe1`	Specify the interface `(xe1)` to be configured
`PE2(config-if)#ip address 20.20.20.2/24`	Configure IP address for the interface
`PE2(config-if)#no shutdown`	Administratively bringing up the interface
`PE2(config-if)#exit`	Exit interface mode
`PE2(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`PE2(config-router)#ospf router-id 3.3.3.3`	Configure OSPF router ID same as loopback IP address
`PE2(config-router)#network 20.20.20.0/24 area 0` `PE2(config-router)#network 3.3.3.3/32 area 0`	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface
`PE2(config-router)#exit`	Exit router mode
`PE2(config)#router ldp`	Enter router mode for LDP
`PE2(config-router)#router-id 3.3.3.3`	Set the router ID to IP address 3.3.3.3
`(config-router)#transport-address ipv4 3.3.3.3`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`PE2(config-router)# targeted-peer ipv4 1.1.1.1`	Configure targeted peer.
`PE1(config-router-targeted-peer)#exit`	Exit from router target peer and LDP mode
`PE2(config-router)#exit`	Exit router mode for LDP
`PE2(config)#interface xe1`	Specify the interface (xe1) to be configured
`PE2(config-if)#label-switching`	Enabling label switching capability on router
`PE2(config-if)#enable-ldp ipv4`	Enabling ldp on interface
`PE2(config-if)#commit`	Commit the transaction.

Validation

```
PE1#show ldp
Router ID                  : 1.1.1.1
LDP Version                : 1
Fast-reroute Per-prefix    : Disabled
Global Merge Capability    : Merge Capable
Label Advertisement Mode   : Downstream Unsolicited
Label Retention Mode       : Liberal
Label Control Mode         : Independent
Instance Loop Detection    : Off
Request Retry              : Off
Propagate Release          : Disabled
Graceful Restart           : Disabled
Hello Interval             : 5
Targeted Hello Interval    : 15
Hold time                  : 15
Targeted Hold time         : 45
Keepalive Interval         : 10
Keepalive Timeout          : 30
Request retry Timeout      : 5
Auto Targeted Hello Receipt    : Disabled
Transport Address data     :
  Labelspace 0             : 1.1.1.1 (in use)
Import BGP routes          : No

PE1#show ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/Backup      00:00:30    10.10.10.2      xe1                  0


P#show ldp
Router ID                  : 2.2.2.2
LDP Version                : 1
Global Merge Capability    : Merge Capable
Label Advertisement Mode   : Downstream Unsolicited
Label Retention Mode       : Liberal
Label Control Mode         : Independent
Instance Loop Detection    : Off
Request Retry              : Off
Propagate Release          : Disabled
Graceful Restart           : Disabled
Hello Interval             : 5
Targeted Hello Interval    : 15
Hold time                  : 15
Targeted Hold time         : 45
```

```
Keepalive Interval       : 10
Keepalive Timeout        : 30
Request retry Timeout    : 5
Auto Targeted Hello Receipt: Disabled
Transport Address data   :
  Labelspace 0           : 2.2.2.2 (in use)
Import BGP routes        : No

P#show mpls label-space 0

Label range (min - max)         : 1000 - 50000

 module-static
      Default range             : 1000 - 3839

 module-srgb
      Default range (Usable)    : 3840 - 8739
      Default range (Allotted)  : 3840 - 8959

 module-srlb
      Default range (Usable)    : 8960 - 9959
      Default range (Allotted)  : 8960 - 10239

 module-rsvp
      Configured range          : N/A
      Current dynamic range     : N/A

 module-ldp
      Configured range          : Not configured
      Current dynamic range     : 10880 - 11519

 module-ldp-vc
      Configured range          : Not configured
      Current dynamic range     : 11520 - 12159

 module-bgp
      Configured range          : N/A
      Current dynamic range     : N/A

P#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
10.12.49.142     1   Full/DR         00:00:34    10.10.10.1      xe1                0
10.12.49.158     1   Full/Backup      00:00:36    20.20.20.2      xe6               0

P#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
```

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```
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label   Out-Label   In-Intf    Out-Intf/VRF
Nexthop                  pri    LSP-Type
   L>   1.1.1.1/32         2          10881       3           N/A        eth3
10.10.10.1               Yes    LSP_DEFAULT
   L>   3.3.3.3/32         1          10880       3           N/A        eth2
20.20.20.2               Yes    LSP_DEFAULT

PE2#show ldp
Router ID                 : 3.3.3.3
LDP Version               : 1
Fast-reroute Per-prefix  : Disabled
Global Merge Capability  : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode      : Liberal
Label Control Mode        : Independent
Instance Loop Detection  : Off
Request Retry             : Off
Propagate Release         : Disabled
Graceful Restart          : Disabled
Hello Interval            : 5
Targeted Hello Interval  : 15
Hold time                 : 15
Targeted Hold time        : 45
Keepalive Interval        : 10
Keepalive Timeout         : 30
Request retry Timeout     : 5
Auto Targeted Hello Receipt    : Disabled
Transport Address data    :
  Labelspace 0            : 3.3.3.3 (in use)
Import BGP routes         : No

PE2#show ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address          Interface
Instance ID
2.2.2.2          1   Full/Backup      00:00:29    20.20.20.1      xe1                  0
```

CHAPTER 2 Understanding MPLS TTL Processing

This chapter contains configurations for MPLS-TTL-Processing. It also provides an overview of MPLS-TTL-Processing concepts.

Overview

This feature performs 'Time To Live' (TTL) processing for Multi-Protocol Label Switching (MPLS) packets. The TTL processing is decided by the model chosen by you. This feature provides TTL processing of MPLS packets on ingress, egress, and intermediate routers. TTL processing is compliant with RFC 3443.

The details of TTL processing vary with the tunnel model that is configured for TTL processing. The incoming and outgoing TTL of the packet is determined by the configured tunnel model. Two Models are supported, pipe model and uniform model. Pipe model is default, where MPLS header TTL Value wont get propagated to IP header.

While pipe mode is the default, you can choose the uniform model with the mpls lsp-model uniform command.

For more about the uniform model and pipe models, see MPLS DiffServ Configuration .

Topology

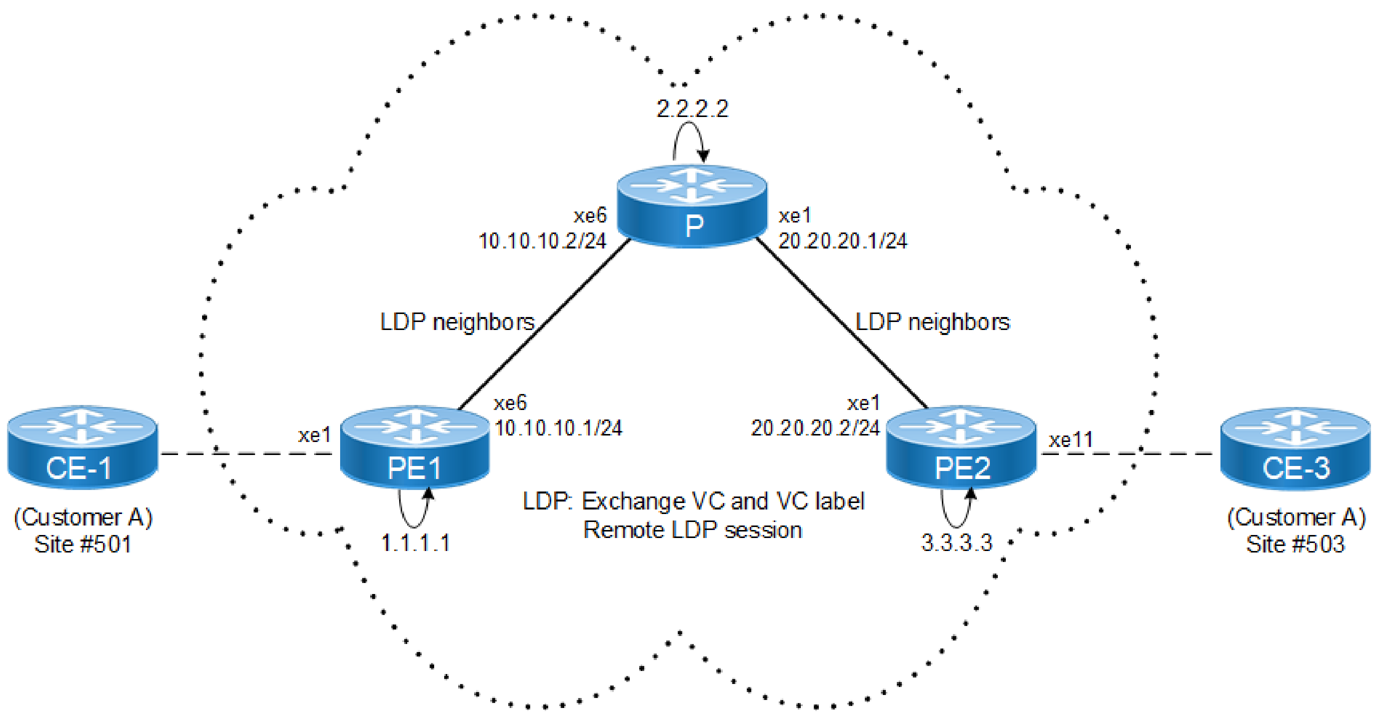

Figure 2-13: TTL Processing Topology

Configuration

PE1

PE1#configure terminal	Enter configure mode
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback address
PE1(config-if)#exit	Exit interface mode
PE1(config)#interface xe6	Specify the interface (xe6) to be configured
PE1(config-if)#ip address 10.10.10.1/24	Configure IP address for the interface
PE1(config-if)#no shutdown	Administratively bringing up the interface
PE1(config-if)#exit	Exit interface mode
PE1(config)#router ospf 100	Configure the routing process and specify the Process ID (100)
PE1(config-router)#ospf router-id 1.1.1.1	Configure ospf router id same as loopback ip address.
PE1(config-router)#network 10.10.10.0/24 area 0 PE1(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface
PE1(config-router)#exit	Exit configure mode
PE1(config)#router ldp	Enter router mode for LDP
PE1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
PE1(config-router)#transport-address ipv4 1.1.1.1 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. **Note:** It is preferable to use the loopback address as the transport address.
PE1(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
PE1(config-router)#exit	Exit router mode for LDP
PE1(config)#interface xe6	Specify the interface (xe6)to be configured
PE1(config-if)#label-switching	Enabling label switching capability on router
PE1(config-if)#enable-ldp ipv4	Enabling ldp on interface
PE1(config-if)#commit	Commit the transaction

P

P#configure terminal	Enter configure mode.
P(config)#interface lo	Enter interface mode.
P(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback address
P(config-if)#exit	Exit interface mode
P(config)#interface xe6	Specify the interface (xe6) to be configured
P(config-if)#ip address 10.10.10.2/24	Configure IP address for the interface
P(config-if)#no shutdown	Administratively bringing up the interface
P(config)#interface xe1	Specify the interface (xe1) to be configured

`P(config-if)#ip address 20.20.20.1/24`	Configure IP address for the interface
`P(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`P(config-router)#ospf router-id 2.2.2.2`	Configure OSPF router id same as loopback IP address.

`P(config-router)#network 10.10.10.0/24 area 0`
`P(config-router)#network 20.20.20.0/24 area 0`
`P(config-router)#network 2.2.2.2/32 area 0`
	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface

`P(config-router)#exit`	Exit router mode
`P(config)#router ldp`	Enter router mode for LDP
`P(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2
`P(config-router)#transport-address ipv4 2.2.2.2 0`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note:It is preferable to use the loopback address as the transport address.
`P(config-router)#exit`	Exit router mode for LDP
`P(config)#interface xe6`	Specify the interface (xe6)to be configured
`P(config-if)#label-switching`	Enabling label switching capability on router
`P(config-if)#enable-ldp ipv4`	Enabling ldp on interface
`P(config)#interface xe1`	Specify the interface (xe1)to be configured
`P(config-if)#label-switching`	Enabling label switching capability on router
`P(config-if)#enable-ldp ipv4`	Enabling ldp on interface
`P(config-if)#commit`	Commit the transaction

PE2

`PE2#configure terminal`	Enter configure mode.
`PE2(config)#interface lo`	Enter interface mode.
`PE2(config-if)#ip address 3.3.3.3/32 secondary`	Configure IP address for the loopback address
`PE2(config-if)#exit`	Exit interface mode
`PE2(config)#interface xe1`	Specify the interface `(xe1)` to be configured
`PE2(config-if)#ip address 20.20.20.2/24`	Configure IP address for the interface
`PE2(config-if)#no shutdown`	Administratively bringing up the interface
`PE2(config-if)#exit`	Exit interface mode
`PE2(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`PE2(config-router)#ospf router-id 3.3.3.3`	Configure OSPF router ID same as loopback IP address.
`PE2(config-router)#network 20.20.20.0/24 area 0` `PE2(config-router)#network 3.3.3.3/32 area 0`	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface
`PE2(config)#router ldp`	Enter router mode for LDP
`PE2(config-router)#router-id 3.3.3.3`	Set the router ID to IP address 3.3.3.3

PE2(config-router)#transport-address ipv4 3.3.3.3 0	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. **Note:** It is preferable to use the loopback address as the transport address.
PE2(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
PE2 (config-router-targeted-peer)#exit	Exit-targeted-peer-mode
PE2(config-router)#exit	Exit router mode for LDP
PE2(config)#interface xe1	Specify the interface (xe1)to be configured
PE2(config-if)#label-switching	Enabling label switching capability on router
PE2(config-if)#enable-ldp ipv4	Enabling ldp on interface
PE2(config-if)#commit	Commit the transaction

Validation

```
PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID
2.2.2.2      1   Full/DR         00:00:31    10.10.10.2      xe6                   0

PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
3.3.3.3                   xe6       Passive   OPERATIONAL   30    00:03:03
2.2.2.2                   xe6       Passive   OPERATIONAL   30    00:03:46


P#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 100 VRF(default):
Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID
1.1.1.1            1   Full/Backup     00:00:37    10.10.10.1      xe6
0
3.3.3.3      1   Full/DR         00:00:34    20.20.20.2      xe1                   0

P#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
3.3.3.3                   xe1       Passive   OPERATIONAL   30    00:06:21
1.1.1.1                   xe6       Active    OPERATIONAL   30    00:06:39


PE2#show ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
```

```
Neighbor ID      Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2      1   Full/Backup      00:00:37    20.20.20.1      xe1                   0

PE2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
1.1.1.1                   xe1       Active    OPERATIONAL   30    00:06:07
2.2.2.2                   xe1       Active    OPERATIONAL   30    00:06:33



PE1#ping 3.3.3.3
Press CTRL+C to exit
PING 3.3.3.3 (3.3.3.3) 56(84) bytes of data.
64 bytes from 3.3.3.3: icmp_seq=1 ttl=63 time=2.17 ms
64 bytes from 3.3.3.3: icmp_seq=2 ttl=63 time=2.26 ms
64 bytes from 3.3.3.3: icmp_seq=3 ttl=63 time=2.11 ms
64 bytes from 3.3.3.3: icmp_seq=4 ttl=63 time=1.91 ms

--- 3.3.3.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 8ms
rtt min/avg/max/mdev = 1.912/2.112/2.261/0.127 ms


PE1#traceroute 2.2.2.2
traceroute to 2.2.2.2 (2.2.2.2), 30 hops max, 60 byte packets
 1  2.2.2.2 (2.2.2.2)  1.172 ms  0.918 ms  0.983 ms

PE1#traceroute 3.3.3.3
traceroute to 3.3.3.3 (3.3.3.3), 30 hops max, 60 byte packets
 1  * * *
 2  3.3.3.3 (3.3.3.3)  5.440 ms  5.215 ms  5.305 ms
```

CHAPTER 3 MPLS Layer-3 VPN Configurations

This chapter contains configurations for MPLS Layer-3 Virtual Private Networks (VPNs).

Overview

The MPLS Layer-3 VPN solution provides address space and routing separation via the use of per-VPN Routing and Forwarding tables (VRFs), and MPLS switching in the core and at the edge of the network. VPN customer routing data is imported into the VRFs utilizing the Route Target BGP extended community. This routing data is identified by a Route Distinguisher (RD) and is distributed among Provider Edge (PE) routers using Multi-Protocol BGP extensions.

Terminology

The following illustrates a Virtual Private Network in a CConnect Service Provider Network. This illustration corresponds to the terms defined in this subsection.

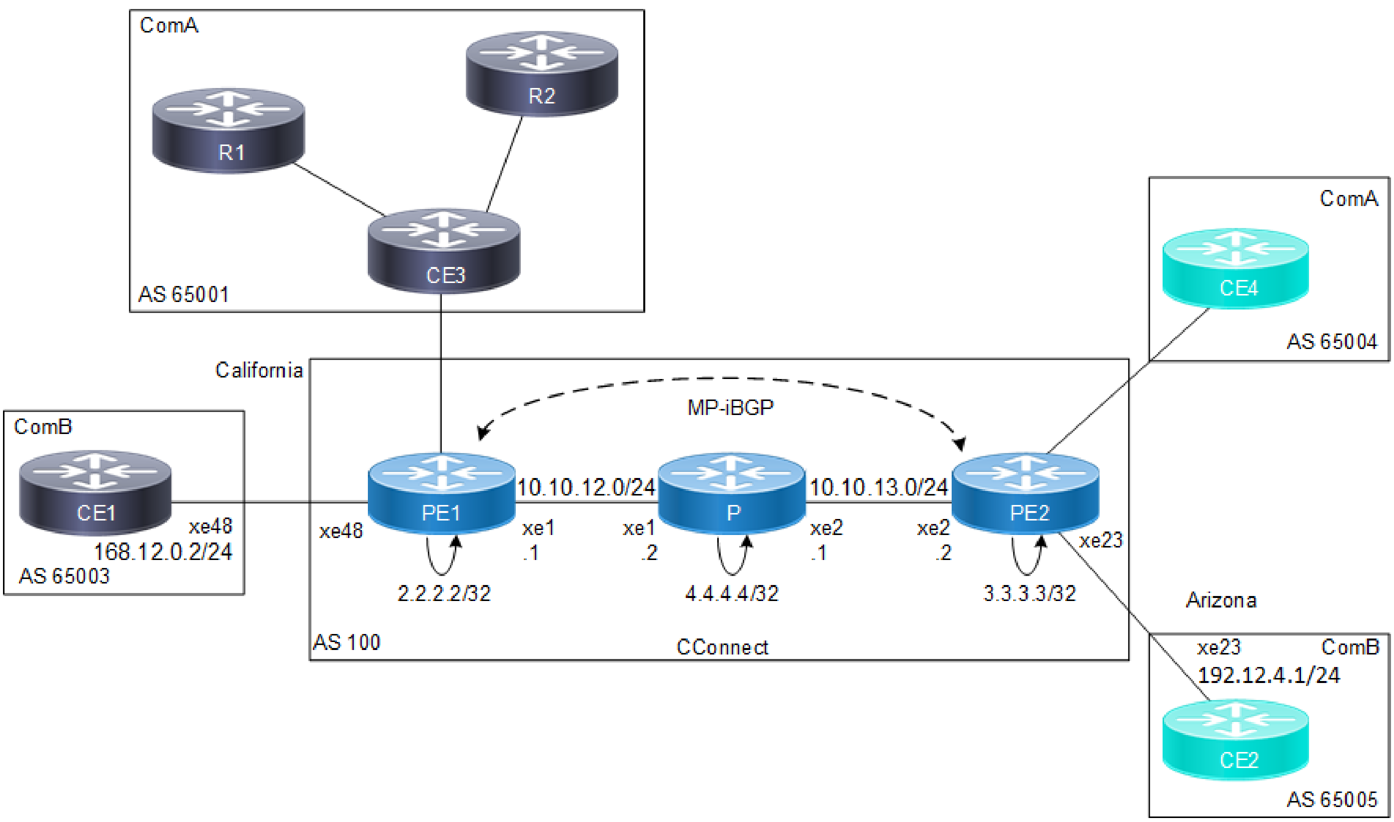

Figure 3-14: CConnect Provider with ComA and ComB Customers

- Service Provider

  The organization that owns the infrastructure that provides leased lines to customers, offering them a Virtual Private Network Service. In the above illustration, CConnect is the service provider providing services to clients ComA and ComB.

- Customer Edge (CE) Router

  A router at a customer's site that connects to the Service Provider via one or more Provider Edge routers. In the above illustration, CE1, CE2, CE3 and CE4 are all CE routers connected directly to the CConnect network.

- Provider Edge (PE) Router

  A provider's router connected to a CE router through a leased line or dial-up connection. In the above illustration, PE1 and PE2 are the PE routers, because they link the CConnect service provider to its clients.

- Provider Core Router (P)

  The devices in the core of the service provider network, which are generally not Provider Edge routers. In the above illustration, the P router is the Provider device, not connected to any customer, and is the core of the CConnect network.

- Site

  A contiguous part of the customer network. A site connects to the provider network through transmission lines, using a CE and PE router. In the above illustration, R1, R2 and CE3 comprise a Customer network, and are seen as a single site by the CConnect network.

- Customer Router

  In the illustration above, R1 and R2 are the Customer routers, and are not directly connected to the CConnect network.

VPN Routing Process

The OcNOS MPLS-VPN Routing process follows these steps:

1. Service Providers provide VPN services from PE routers that communicate directly with CE routers via an Ethernet Link.

2. Each PE router maintains a Routing and Forwarding table (VRF) for each customer. This guarantees isolation, and allows the usage of uncoordinated private addresses. When a packet is received from the CE, the VRF that is mapped to that site is used to determine the routing for the data. If a PE has multiple connections to the same site, a single VRF is mapped to all of those connections.

3. After the PE router learns of the IP prefix, it converts it into a VPN-IPv4 prefix by prepending it with an 8-byte Route Distinguisher (RD). The RD ensures that even if two customers have the same address, two separate routes to that address can be maintained. These VPN-IPv4 addresses are exchanged between the PE routers through MP-BGP.

4. A unique Router ID (usually the loopback address) is used to allocate a label, and enable VPN packet forwarding across the backbone.

5. Based on routing information stored in the VRF table, packets are forwarded to their destination using MPLS. Each PE router allocates a unique label to every route in each VRF (even if they have the same next hop), and propagates these labels, together with 12-byte VPN-IPv4 addresses, through Multi-Protocol BGP.

6. Ingress PE routers prepend a two-level label stack to the VPN packet, which is forwarded across the Provider network. This label stack contains a BGP-specific label from the VRF table (associated with the incoming interface), specifying the BGP next hop and an LDP-specific label from the global FTN table, specifying the IP next hop.

7. The Provider router in the network switches the VPN packet, based on the top label or the LDP-specific label in the stack. This top label is used as the key to lookup in the incoming interface's Incoming Labels Mapping table (ILM). If there is an outbound label, the label is swapped, and the packet is forwarded to the next hop; if not, the router is the penultimate router, and it pops the LDP-specific label, and forwards the packet with only the BGP-specific label to the egress PE router.

8. The egress PE router pops the BGP-specific label, performs a single label lookup in the outbound interface, and sends the packet to the appropriate CE router.

Configure MPLS Layer-3 VPN

The MPLS Layer-3 VPN configuration process can be divided into the following tasks

1. Establish connection between PE routers.
2. Configure PE1 and PE2 as iBGP neighbors.
3. Create VRF.
4. Associate interfaces to VRFs.
5. Configure VRF Route Destination and Route Targets.
6. Configure CE neighbor for the VPN.
7. Verify the MPLS to VPN configuration.

Topology

In this example, the CConnect MPLS-VPN backbone has two customers — ComA and ComB. Both customers have sites in California and Arizona. The following topology shows BGP4 address assignment between PE and CE routers. The steps that follow provision a customer VPN service across the MPLS-VPN backbone.

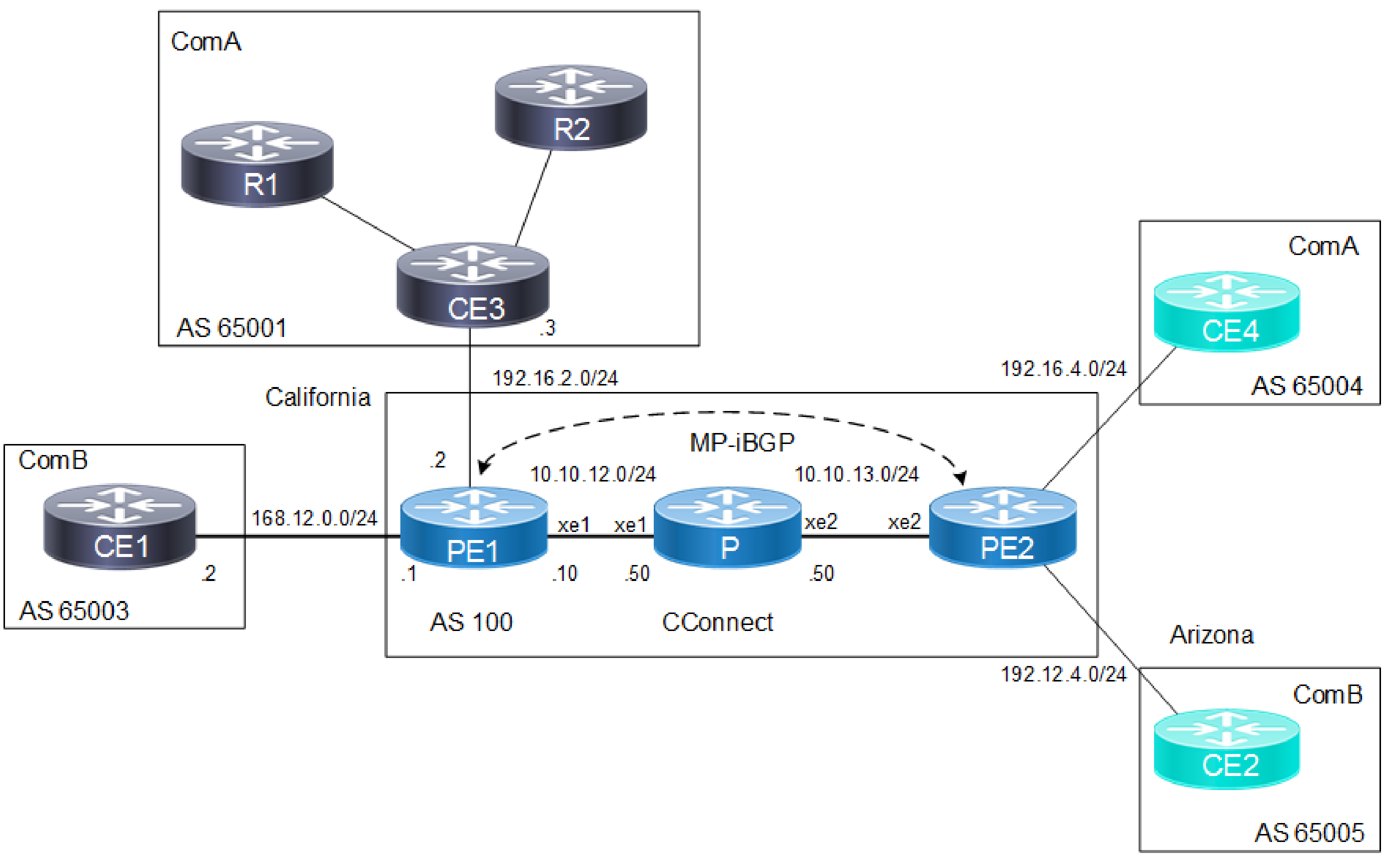

Figure 3-15: Connect Sample Topology

To establish this connection involves three steps:

Enable Label Switching

This is a sample configuration to enable label switching for the Labeled Switched Path (LSP) between PE1 and PE2 (refer to Figure 3-15).

Enable Label Switching: PE1

configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 2.2.2.2/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 10.10.12.1/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.

Enable Label Switching: P

configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 4.4.4.4/32 area 0 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter Interface mode
(config-if)#ip address 10.10.12.2/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.
(config)#interface xe2	Enter Interface mode
(config-if)#ip address 10.10.13.1/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.

Enable Label Switching: PE2

configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IPv4 address
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter Interface mode
(config-if)#ip address 10.10.13.2/24	Assign IPv4 address
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#commit	Commit the transaction.

Enable IGP

What follows is a sample configuration to establish connections between the two Provider Edge routers PE1 and PE2.

Enable IGP Switching: PE1

`configure terminal`	Enter configure mode
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`(config-router)#network 10.10.12.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#network 2.2.2.2/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#commit`	Commit the transaction.

Enable IGP Switching: P

`configure terminal`	Enter configure mode
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`(config-router)#network 10.10.12.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#network 10.10.13.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#network 4.4.4.4/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#commit`	Commit the transaction.

Enable IGP Switching: PE2

`configure terminal`	Enter configure mode
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100)
`(config-router)#network 3.3.3.3/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#commit`	Commit the transaction.

Enable Label Switching Protocol

Label switching protocols are used to set up a Label-Switched Path (LSP) between PE routers. OcNOS supports LDP and RSVP-TE protocols for label switching. Enable either LDP or RSVP-TE.

This is a sample configuration to enable LDP on the whole path between PE1 and PE2 (see Figure 3-15).

LDP: PE1

`configure terminal`	Enter configure mode
`(config)#router ldp`	Enter router mode for LDP

`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode
`(config-if)#enable-ldp ipv4`	Enabling LDP on interface
`(config-if)#commit`	Commit the transaction.

LDP: P

`configure terminal`	Enter configure mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode
`(config-if)#enable-ldp ipv4`	Enabling LDP on interface
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode
`(config-if)#enable-ldp ipv4`	Enabling LDP on interface
`(config-if)#commit`	Commit the transaction.

LDP: PE2

`configure terminal`	Enter configure mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#exit`	Exit router mode
`(config)#interface xe2`	Enter interface mode
`(config-if)#enable-ldp ipv4`	Enabling LDP on interface
`(config-if)#commit`	Commit the transaction.

This is a sample configuration to enable RSVP-TE along the entire path between PE1 and PE2 (see Figure 3-15).

RSVP-TE: PE1

`configure terminal`	Enter configure mode
`(config)#router rsvp`	Enter Configure Router mode
`(config-router)#rsvp-path p1 mpls`	Enter the path mode for RSVP P1.
`(config-path)#10.10.12.2 loose`	Configure loose path
`(config-path)#exit`	Exit Configure Router mode
`(config)#rsvp-trunk t1`	Configure RSVP trunk t1
`(config-rsvp)#primary path p1`	Specify an RSVP path to be used
`(config-rsvp)#from 2.2.2.2`	Assign the source loopback address to the RSVP trunk
`(config-rsvp)#to 3.3.3.3`	Assign the source loopback address to the to the RSVP trunk
`(config-rsvp)#exit`	Exit RSVP trunk mode
`(config)#interface xe1`	Enter the interface mode
`(config-if)#enable-rsvp`	Enable RSVP in interface
`(config-if)#commit`	Commit the transaction.

RSVP-TE: P

`configure terminal`	Enter configure mode
`(config)#router rsvp`	Enter Configure Router mode
`(config-router)#exit`	Exit Configure Router mode
`(config)#interface xe1`	Enter the interface mode
`(config-if)#enable-rsvp`	Enable RSVP in interface
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter the interface mode
`(config-if)#enable-rsvp`	Enable RSVP in interface
`(config-if)#commit`	Commit the transaction.

RSVP-TE: PE2

`configure terminal`	Enter configure mode
`(config)#router rsvp`	Enter Configure Router mode
`(config-router)#rsvp-trunk t1`	Configure RSVP trunk t1
`(config-rsvp)#from 3.3.3.3`	Assign the source loopback address to the RSVP trunk
`(config-rsvp)#to 2.2.2.2`	Assign the source loopback address to the to the RSVP trunk
`(config-rsvp)#exit`	Exit RSVP trunk mode
`(config)#interface xe2`	Enter the interface mode
`(config-if)#enable-rsvp`	Enable RSVP in interface
`(config-if)#commit`	Commit the transaction.

Configure PEs as BGP Neighbors

BGP is the preferred protocol to transport VPN routes because of its multiprotocol capability and its scalability. Its ability to exchange information between indirectly connected routers supports keeping VPN routing information out of the Provider (P) routers. The P routers carry information as an optional BGP attribute. Additional attributes are transparently forwarded by any P router. The MPLS-VPN forwarding model does not require the P routers to make routing decisions based on VPN addresses: They forward packets based on the label value attached to the packet. The P routers do not require a VPN configuration in order to carry this information.

PE1

`#configure terminal`	Enter the configure terminal
`(config)#router bgp 100`	Enter the Router BGP mode, ASN: 100
`(config-router)#bgp router-id 2.2.2.2`	Router identifier for BGP
`(config-router)#exit`	Exit router BGP mode
`(config)#router ldp`	Enter the Router LDP mode
`(config-router)#exit`	Exit the Router LDP mode
`(config)#router bgp 100`	Enter the Router BGP mode, ASN: 100
`(config-router)#neighbor 3.3.3.3 remote-as 100`	Configuring ABR1 as iBGP neighbor using it's loopback IP

(config-router)#neighbor 3.3.3.3 update-source 2.2.2.2	Source of routing updates
(config-router)#address-family vpnv4 unicast	Configure VPNv4 address family
(config-router-af)#neighbor 3.3.3.3 activate	Activate the VPN neighbor
(config-router-af)exit-address-family	Exit address family mode
(config-router)#address-family ipv4 unicast	Configure IPv4 address family
(config-router-af)#neighbor 3.3.3.3 activate	Activate the IPv4 neighbor
(config-router-af)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#bgp router-id 3.3.3.3	Router identifier for BGP
(config-router)#exit	Exit router BGP mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#exit	Exit the Router LDP mode
(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)#neighbor 2.2.2.2 remote-as 100	Configuring ABR1 as iBGP neighbor using it's loopback IP
(config-router)#neighbor 2.2.2.2 update-source 3.3.3.3	Source of routing updates
(config-router)#address-family vpnv4 unicast	Configure VPNv4 address family
(config-router-af)#neighbor 2.2.2.2 activate	Activate the VPN neighbor
(config-router-af)exit-address-family	Exit address family mode
(config-router)#address-family ipv4 unicast	Configure IPv4 address family
(config-router-af)#neighbor 2.2.2.2 activate	Activate the IPv4 neighbor
(config-router-af)#commit	Commit the transaction.

Create VRF

Each PE router in the MPLS-VPN backbone is attached to a site that receives routes from a specific VPN, so the PE router must have the relevant Virtual Routing and Forwarding (VRF) configuration for that VPN.

This command creates a VRF RIB (Routing Information Base), assigns a VRF-ID, and switches the command mode to `vrf` mode. The following example creates a VRF named `ComB`.

PE1

#configure terminal	Enter the configure terminal
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 2:1	Configure Router Distinguisher value
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 1:2	Configure Router Distinguisher value

(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:2	Configure Router Distinguisher value
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:1	Configure Router Distinguisher value
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

Associate Interfaces to VRFs

After the VRFs are defined on the PE router, the PE router needs to recognize which interfaces belong to which VRF. The VRF is populated with routes from connected sites. More than one interface can belong to the same VRF.

In the following example, interface `xe48` is associated with the VRF named `ComB`.

PE1

#configure terminal	Enter the configure terminal
(config)#interface xe49	Enter interface mode
(config-if)#ip vrf forwarding ComA	Bind the VRF instance to the interface
(config-if)exit	Exit interface mode
(config)#interface xe48	Enter interface mode
(config-if)#ip vrf forwarding ComB	Bind the VRF instance to the interface
(config-if)#ip address 168.12.0.3/24	Assign IPv4 address
PE1(config-if)#ip vrf forwarding ComA	Bind the VRF instance to the interface
(config-if)exit	Exit interface mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#interface xe48	Enter interface mode
(config-if)#ip vrf forwarding ComA	Bind the VRF instance to the interface
(config-if)#ip address 192.16.4.2/24	Assign IPv4 address
(config-if)exit	Exit interface mode
(config)#interface xe49	Enter interface mode
(config-if)#ip vrf forwarding ComB	Bind the VRF instance to the interface
(config-if)#ip address 168.12.4.2/24	Assign IPv4 address

(config-if)exit	Exit interface mode
(config)#commit	Commit the transaction.

Configure VRF—RD and Route Targets

After the VRF is created, configure Router Distinguishers and the Route Targets.

Configure Route Distinguishers

Route Distinguishers (RDs) make all customer routes unique. The routes must be unique, so that Multi-Protocol BGP treats the same prefix from two different VPNs as non-comparable routes. To configure RDs, a sequence of 64 bits is prepended to the IPv4 address in the Multi-Protocol BGP update. BGP considers two IPv4 addresses with different RDs as non-comparable, even if they have the same address and mask.

Assign a particular value to the RD for each VRF on the PE router. To display the routing table for a VRF, use the `show ip route vrf` command.

The following example shows adding an RD. Configure a VRF in both PEs with a unique RD value:

PE1

#configure terminal	Enter the configure terminal
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:2	Configure Router Distinguisher value
(config-vrf)#route-target both 200:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:1	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter the configure terminal
(config)#ip vrf ComA	Configure VRF instance
(config-vrf)#rd 2:1	Configure Router Distinguisher value
(config-vrf)#route-target both 200:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#ip vrf ComB	Configure VRF instance
(config-vrf)#rd 1:2	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit VRF mode
(config)#commit	Commit the transaction.

Configure Route Targets

Any routes learned from customers are advertised across the network through Multi-Protocol BGP, and any routes learned through Multi-Protocol BGP are added into the appropriate VRFs. The route target helps PE routers identify which VRFs should receive the routes.

The `route-target` command creates lists of import and export route-target extended communities for the VRF. It specifies a target VPN extended community. Execute the command once for each community. All routes with the specific route-target extended community are imported into all VRFs with the same extended community as an import route-target.

The following example demonstrates the route-target configuration.

PE1

`#configure terminal`	Enter the configure terminal
`(config)#ip vrf ComA`	Configure VRF instance
`(config-vrf)#rd 2:2`	Configure Router Distinguisher value
`(config-vrf)#route-target both 200:1`	Configure route-target as both
`(config-vrf)#exit`	Exit VRF mode
`(config)#ip vrf ComB`	Configure VRF instance
`(config-vrf)#rd 1:1`	Configure Router Distinguisher value
`(config-vrf)#route-target both 100:1`	Configure route-target as both
`(config-vrf)#exit`	Exit VRF mode
`(config)#commit`	Commit the transaction.

PE2

`#configure terminal`	Enter the configure terminal
`(config)#ip vrf ComA`	Configure VRF instance
`(config-vrf)#rd 2:1`	Configure Router Distinguisher value
`(config-vrf)#route-target both 200:1`	Configure route-target as both
`(config-vrf)#exit`	Exit VRF mode
`(config)#ip vrf ComB`	Configure VRF instance
`(config-vrf)#rd 1:2`	Configure Router Distinguisher value
`(config-vrf)#route-target both 100:1`	Configure route-target as both
`(config-vrf)#exit`	Exit VRF mode
`(config)#commit`	Commit the transaction.

Configure CE Neighbor for the VPN (Using BGP/ OSPF)

To provide a VPN service, the PE-router must be configured so that any routing information learned from a VPN customer interface can be associated with a particular VRF. This is achieved using any standard routing protocol process (OSPF, BGP or static routes etc). Use any one of the following configurations (BGP, or OSPF) to configure the CE neighbor.

Using BGP

The BGP sessions between PE and CE routers can carry different types of routes (VPN-IPv4, IPv4 routes). Address families are used to control the type of BGP session. Configure a BGP address family for each VRF on the PE-router, and a separate address family to carry VPN-IPv4 routes between PE routers. All non-VPN BGP neighbors are defined using the `IPv4 address` mode. Each VPN BGP neighbor is defined under its associated address family mode.

A separate address family entry is used for every VRF, and each address family entry can have multiple CE routers within the VRF.

The PE and CE routers must be directly connected for BGP4 sessions; BGP multihop is not supported between PE and CE routers.

The following example places the router in address family mode, and specifies company names, `ComA` and `ComB`, as the names of the VRF instance to associate with subsequent IPv4 address family configuration mode commands. This configuration is used when BGP is used for PE and CE.

PE1

`configure terminal`	Enter configure mode
`(config)#router bgp 100`	Enter BGP router mode
`(config-router)#address-family ipv4 unicast`	Enter address family mode
`(config-router-af)#redistribute connected`	Redistribute connected addresses
`(config-router-af)#exit-address-family`	Exit address family mode
`(config-router)#address-family ipv4 vrf ComA`	Enter the IPv4 address family for VRF comA
`(config-router)#neighbor 192.16.2.3 remote-as 65001`	Specify the neighbor
`(config-router-af)#neighbor 192.16.2.3 activate`	Activate the neighbor
`(config-router-af)#exit-address-family`	Exit address family mode
`(config-router)#address-family ipv4 vrf ComB`	Enter the IPv4 address family for VRF comA
`(config-router)#neighbor 168.12.0.2 remote-as 65003`	Specify the neighbor
`(config-router-af)#neighbor 192.12.0.2 activate`	Activate the neighbor
`(config-router-af)#exit-address-family`	Exit address family mode
`(config-router)#commit`	Commit the transaction

PE2

`configure terminal`	Enter configure mode
`(config)#router bgp 100`	Enter BGP router mode
`(config-router)#address-family ipv4 unicast`	Enter address family mode
`(config-router-af)#redistribute connected`	Redistribute connected addresses
`(config-router-af)#exit-address-family`	Exit address family mode
`(config-router)#address-family ipv4 vrf ComA`	Enter the IPv4 address family for VRF comA
`(config-router)#neighbor 192.16.4.3 remote-as 65004`	Specify the neighbor

(config-router-af)#neighbor 192.16.4.3 activate	Activate the neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family ipv4 vrf ComB	Enter the IPv4 address family for VRF comA
(config-router)#neighbor 168.12.4.1 remote-as 65005	Specify the neighbor
(config-router-af)#neighbor 192.12.4.1 activate	Activate the neighbor
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#commit	Commit the transaction

CE1: BGP

configure terminal	Enter configure mode
(config)#interface xe48	Enter interface mode for xe48
(config-if)#ip address 168.12.0.2/24	Assign IP address
(config-if)#exit	Exit interface mode
(config)#router bgp 65003	Enter BGP router mode
(config-router)#neighbor 168.12.0.3 remote-as 100	Specify the neighbor
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 168.12.0.3 activate	Activate the neighbor
(config-router-af)#redistribute connected	Redistribute connected addresses
(config-router-af)#commit	Commit the transaction

CE2: BGP

configure terminal	Enter configure mode
(config)#interface xe23	Enter interface mode for xe48
(config-if)#ip address 192.12.4.1/24	Assign IP address
(config-if)#exit	Exit interface mode
(config)#router bgp 65005	Enter BGP router mode
(config-router)#neighbor 192.12.4.2 remote-as 100	Specify the neightbor
(config-router)#address-family ipv4 unicast	Enter address family mode
(config-router-af)#neighbor 192.12.4.2 activate	Activate the neighbor
(config-router-af)#redistribute connected	Redistribute connected addresses
(config-router-af)#commit	Commit the transaction

Using OSPF

Unlike BGP, OSPF does not run different routing contexts within one process. Thus, for running OSPF between the PE and CE routers, configure a separate OSPF process for each VRF that receives VPN routes through OSPF. The PE

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router distinguishes routers belonging to a specific VRF, by associating a particular customer interface to a specific VRF and to a particular OSPF process.

To redistribute VRF OSPF routes into BGP, redistribute OSPF under the BGP VRF address family submode.

PE1

`configure terminal`	Enter configure mode
`(config)#router ospf 101 comA`	Enter OSPF router mode
`(config-router)#network 192.16.3.0/24 area 0`	Define the network on which OSPF runs and associate area ID
`(config-router)#redistribute bgp`	Redistribute BGP
`(config-router)#exit`	Exit router mode
`(config)#router ospf 102 comB`	Enter OSPF router mode
`(config-router)#network 168.12.0.2/24 area 0`	Define the network on which OSPF runs and associate area ID
`(config-router)#redistribute bgp`	Redistribute BGP
`(config-router)#commit`	Commit the transaction
`(config-router)#exit`	Exit router mode
`(config)#router bgp 100`	Enter the Router BGP mode, ASN: 100
`(config-router)#address-family ipv4 vrf ComA`	Configure VRF address family
`(config-router-af)#redistribute ospf`	Redistribute OSPF
`(config-router-af)#exit-address-family`	Exit address family mode
`(config-router)#address-family ipv4 vrf ComB`	Configure VRF address family
`(config-router-af)#redistribute ospf`	Redistribute OSPF
`(config-router-af)#redistribute rip`	Redistribute RIP
`(config-router-af)#commit`	Commit the transaction

PE2

`configure terminal`	Enter configure mode
`(config)#router ospf 101 comA`	Enter OSPF router mode
`(config-router)#network 192.16.4.0/24 area 0`	Define the network on which OSPF runs and associate area ID
`(config-router)#redistribute bgp`	Redistribute BGP
`(config-router)#exit`	Exit router mode
`(config)#router ospf 102 comB`	Enter OSPF router mode
`(config-router)#network 168.12.0.3/24 area 0`	Define the network on which OSPF runs and associate area ID
`(config-router)#redistribute bgp`	Redistribute BGP
`(config-router)#commit`	Commit the transaction
`(config-router)#exit`	Exit router mode
`(config)#router bgp 100`	Enter the Router BGP mode, ASN: 100
`(config-router)#address-family ipv4 vrf ComA`	Configure VRF address family
`(config-router-af)#redistribute ospf`	Redistribute OSPF

(config-router-af)#exit-address-family	Exit address family mode
(config-router)#address-family ipv4 vrf ComB	Configure VRF address family
(config-router-af)#redistribute ospf	Redistribute OSPF
(config-router-af)#redistribute rip	Redistribute RIP
(config-router-af)#commit	Commit the transaction

Verify the MPLS-VPN Configuration

Use the show ip bgp neighbor command to validate the neighbor session between the CE and the PE routers. Use the `show ip bgp vpnv4 all` command to display all the VRFs and the routes associated with them. The following is sample output for the above commands for the PE1, CE1 and PE2 routers (based on the topology in Figure 3-15).

```
PE1#show ip bgp neighbors
BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 2.2.2.2, remote router ID 3.3.3.3
  BGP state = Established, up for 00:05:09
  Last read 00:00:13, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
  Received 194 messages, 2 notifications, 0 in queue
  Sent 198 messages, 3 notifications, 0 in queue
  Route refresh request: received 2, sent 1
  Minimum time between advertisement runs is 5 seconds
  Update source is 2.2.2.2
 For address family: IPv4 Unicast
  BGP table version 8, neighbor version 8
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  3 accepted prefixes
  3 announced prefixes

 For address family: VPNv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  2 announced prefixes

 Connections established 5; dropped 4
Local host: 2.2.2.2, Local port: 35983
Foreign host: 3.3.3.3, Foreign port: 179
Nexthop: 2.2.2.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:05:14, due to BGP Notification received
Notification Error Message: (Cease/Other Configuration Change.)


BGP neighbor is 168.12.0.2, vrf ComB, remote AS 65003, local AS 100, external
link
```

```
  BGP version 4, local router ID 168.12.0.3, remote router ID 10.12.65.206
  BGP state = Established, up for 00:34:38
  Last read 00:00:14, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
  Received 85 messages, 0 notifications, 0 in queue
  Sent 86 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (standard)
  2 accepted prefixes
  0 announced prefixes

 Connections established 1; dropped 0
Local host: 168.12.0.3, Local port: 179
Foreign host: 168.12.0.2, Foreign port: 36580
Nexthop: 168.12.0.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

CE1#show ip bgp neighbors
BGP neighbor is 168.12.0.3, remote AS 100, local AS 65003, external link
  BGP version 4, local router ID 10.12.65.206, remote router ID 168.12.0.3
  BGP state = Established, up for 00:36:14
  Last read 00:00:10, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
  Received 86 messages, 0 notifications, 0 in queue
  Sent 89 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  2 announced prefixes

 Connections established 1; dropped 0
Local host: 168.12.0.2, Local port: 36580
Foreign host: 168.12.0.3, Foreign port: 179
Nexthop: 168.12.0.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

PE1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best,
i - internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
 Network          Next Hop           Metric    LocPrf     Weight Path
Route Distinguisher: 1:1 (Default for VRF ComB)
*> l 168.12.0.0/24    0.0.0.0             1        100       32768  ?
                168.12.0.2          0        100       0   65003 ?
*>i  192.12.4.0       3.3.3.3             0        100       0   65005 ?
 Announced routes count = 2
 Accepted routes count = 1
Route Distinguisher: 1:2
*>i  192.12.4.0       3.3.3.3             0        100       0   65005 ?
 Announced routes count = 0
 Accepted routes count = 1
Route Distinguisher: 2:2 (Default for VRF ComA)
*> l 192.16.2.0       0.0.0.0             1        100       32768  ?
                192.16.2.3          0        100       0   65001 ?
 Announced routes count = 2
 Accepted routes count = 0

PE1#show ip bgp vpnv4 all neighbors 3.3.3.3 routes

For address family: VPNv4 Unicast
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best,
i - internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

 Network          Next Hop           Metric    LocPrf     Weight Path
Route Distinguisher: 1:2
*>i  192.12.4.0       3.3.3.3             0        100       0   65005 ?
 Accepted routes count = 1

PE2#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:2 (Default for VRF ComB)
*>i  168.12.0.0/24    2.2.2.2             0        100       0    ?
*> l 192.12.4.0       0.0.0.0             0        100       32768  ?
 Announced routes count = 1
 Accepted routes count = 1
Route Distinguisher: 1:2
*>i  168.12.0.0/24    2.2.2.2             0        100       0    ?
 Announced routes count = 0
 Accepted routes count = 1
```

Verify MPLS-L3 VPN VRF Ping and Traceroute

Use the `ping mpls l3vpn` command for the below requirements:

- PE to PE L3VPN ping via VRF
- PE to remote CE Ping via the VRF
- CE to remote PE ping (to the VRF interface facing its customer edge).

- Trace route from PE to PE via VRF
- Trace route from PE to remote CE via VRF
- Commands for ipv6 ping and trace route

1. PE to PE L3VPN Ping via VRF:

```
PE2#ping 168.12.0.1 vrf ComB
Press CTRL+C to exit
PING 168.12.0.1 (168.12.0.1) 56(84) bytes of data.
64 bytes from 168.12.0.1: icmp_seq=1 ttl=64 time=0.695 ms

#
```

2. PE to remote CE Ping via VRF:

```
PE2#ping 168.12.0.2 vrf ComB
Press CTRL+C to exit
PING 168.12.0.2 (168.12.0.2) 56(84) bytes of data.
64 bytes from 168.12.0.2: icmp_seq=1 ttl=63 time=0.776 ms

--- 168.12.0.2 ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 0.776/0.776/0.776/0.000 ms
PE2#
 PE2
```

3. CE to remote PE ping:

```
CE1#ping 168.12.0.1
Press CTRL+C to exit
PING 168.12.0.1 (168.12.0.1) 56(84) bytes of data.
64 bytes from 168.12.0.1: icmp_seq=160 ttl=254 time=0.606 ms
64 bytes from 168.12.0.1: icmp_seq=161 ttl=254 time=0.558 ms
64 bytes from 168.12.0.1: icmp_seq=162 ttl=254 time=0.568 ms
64 bytes from 168.12.0.1: icmp_seq=163 ttl=254 time=0.574 ms
64 bytes from 168.12.0.1: icmp_seq=164 ttl=254 time=0.609 ms

--- 168.12.0.2 ping statistics ---
5 packets transmitted, 5 received, 0 errors, 0% packet loss, time 163002ms
```

4. Trace Route from PE to PE via VRF

```
PE2#traceroute ip 168.12.0.1 vrf ComB
traceroute to 168.12.0.1 (168.12.0.1), 30 hops max, 60 byte packets
1168.12.0.1 (168.12.0.1)  0.706 ms  0.743 ms  0.989 ms
```

5. Trace Route from PE to Remote CE via VRF

```
PE2#traceroute ip 168.12.0.2 vrf ComB
traceroute to 168.12.0.2 (168.12.0.2), 30 hops max, 60 byte packets
 1  168.12.0.1 (168.12.0.1)  0.871 ms  1.006 ms  1.055 ms
2168.12.0.2 (168.12.0.2)  1.965 ms  2.045 ms  2.256 ms
```

CHAPTER 4 MPLS-TE Shared Risk Link Group

Shared Risk Link Groups (SRLG) is a feature which allows the user to establish a backup secondary LSP (label switched path) path or a FRR (fast-reroute) LSP path which is disjoint from the path of the primary LSP. Links which are members of the same SRLG represent resources which share the same risk. For example, fiber links sharing the same conduit or multiple wavelengths sharing the same fiber.

SRLG groups are used to determine which links belong to the same SRLG. To advertise SRLG, the information is part of the IGP TE parameters in an opaque LSA (link state advertisement). It is advertised in a SRLG sub-TLV (type 16) of the existing Link TLV in OSPF.

The SRLG of a path in a label-switched path (LSP) is the set of SRLGs for all the links in the path. When computing the secondary path for an LSP, it is preferable to find a path such that the secondary and primary paths do not have any links in common in case the SRLGs for the primary and secondary paths are disjoint. This ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Backup tunnel path selection with SRLG is done so that a backup tunnel can avoid using links that are in the same SRLG as the interfaces it is protecting. Otherwise, when the protected link fails the backup tunnel fails too.

Configure MPLS-TE Shared Risk Link Group

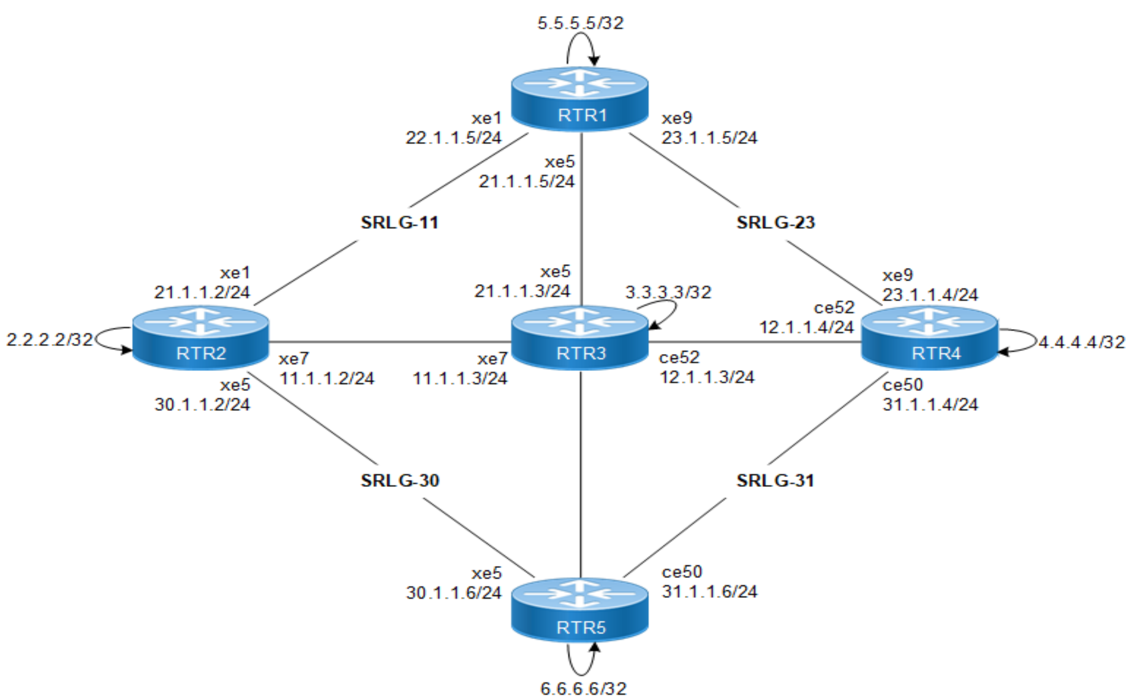

Figure 4-1: Topology for SRLG

RTR2

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the transaction.

MPLS Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#ip address 22.1.1.2/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 30.1.1.2/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#ip address 11.1.1.2/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#router-id 2.2.2.2	Configure OSPF router id
(config-router)#network 2.2.2.2/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 11.1.1.0/24area 0	Advertise network address in OSPF.
(config-router)#network 22.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 30.1.1.0/24area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface

(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#enable-rsvp	Enable rsvp on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

Note: Disjoint type “preferred” can be configured globally using the command `srlg-disjoint preferred`.

SRLG Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 11	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 11	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 30	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

MPLS RSVP Path

(config)#rsvp-path path1	Configure MPLS-path
(config-path)#11.1.1.3 strict	Configure first hop for the path
(config-path)#12.1.1.4 strict	Configure second hop for the path
(config-path)#exit	Exit mpls-path mode and return to Configure mode.
(config)#rsvp-path sec-path1	Configure MPLS-path
(config-path)#4.4.4.4 loose	Configure loose path
(config-path)#exit	Exit mpls-path mode and return to Configure mode.
(config-path)#rsvp-path sec-path2	Configure MPLS-path.
(config-path)#4.4.4.4 loose	Configure loose path
(config-path)#commit	Commit the transaction.

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RSVP-TE Tunnel with Secondary Protection and SRLG Disjoint Type Forced:

`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk lsp1`	Configure rsvp trunk
`(config-trunk)#primary path path1`	Configure primary path
`(config-trunk)#secondary-priority 1 path sec-path1`	Configure secondary path
`(config-trunk)#secondary-priority 1 srlg-disjoint forced`	Configure SRLG for secondary path
`(config-trunk)#secondary-priority 2 path sec-path2`	Configure secondary path
`(config-trunk)#secondary-priority 2 srlg-disjoint forced`	Configure SRLG for secondary path
`(config-trunk)#to 4.4.4.4`	Configure rsvp trunk destination address
`(config-trunk)#commit`	Commit the transaction.

Note: Disjoint type `preferred` can be configured in rsvp-trunk secondary using the command "`secondary-priority 2 srlg-disjoint forced`.

RSVP-TE Tunnel with Fast Reroute Protection One-to-One

`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk lsp2`	Configure rsvp trunk
`(config-trunk)#primary fast-reroute protection one-to-one`	Configure fast-reroute protection
`(config-trunk)#primary path path1`	Configure primary path
`(config-trunk)#to 4.4.4.4`	Configure rsvp trunk destination address
`(config-trunk)#commit`	Commit the transaction.

RSVP-TE Tunnel with Fast Reroute Protection Facility Backup

`#configure terminal`	Enter configure mode.
`(config)#rsvp-bypass bypass1`	Configure rsvp bypass tunnel
`(config-bypass)#path path1`	Configure path for bypass tunnel
`(config-bypass)#to 4.4.4.4`	Configure destination address for tunnel
`(config-bypass)#exit`	Exit rsvp-bypass tunnel mode
`(config)#rsvp-trunk lsp3`	Configure rsvp trunk
`(config-trunk)#primary fast-reroute protection facility`	Configure fast-reroute protection facility
`(config-trunk)#primary path sec-path1`	Configure path
`(config-trunk)#to 4.4.4.4`	Configure the destination of rsvp trunk
`(config-trunk)#commit`	Commit the transaction.

RTR3

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for loopback interface.
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address on loopback interface.
(config-if)#commit	Commit the transaction.

MPLS Interfaces

(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 21.1.1.3/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe7	Enter the Interface mode
(config-if)#ip address 11.1.1.3/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#ip address 12.1.1.3/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)#router-id 3.3.3.3	Configure OSPF router id
(config-router)#network 3.3.3.3/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 11.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 12.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 21.1.1.0/24 area 0	Advertise network address in OSPF.
(config-if)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface

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`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#interface xe7`	Enter the Interface mode
`(config-if)#enable-rsvp`	Enable rsvp on the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#interface ce52`	Enter the Interface mode
`(config-if)#enable-rsvp`	Enable rsvp on the interface
`(config-if)#commit`	Commit the transaction.

Global SRLG (Path Type: Forced)

`(config)#router rsvp`	Enter the Router RSVP mode.
`(config-router)#srlg-disjoint forced`	Configure SRLG path type forced
`(config-router)#commit`	Commit the transaction.

When you use the one-to-one or facility backup protection, you must configure the `srlg- disjoint` type on all routers. When you use the secondary protection type, you only need to configure the `srlg-disjoint` type at the ingress node.de.

SRLG Interface

`(config)#interface xe5`	Enter the Interface mode
`(config-if)#mpls traffic-eng srlg 21`	Configure SRLG value in the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#interface xe7`	Enter the Interface mode
`(config-if)#mpls traffic-eng srlg 11`	Configure SRLG value in the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#interface ce52`	Enter the Interface mode
`(config-if)#mpls traffic-eng srlg 12`	Configure SRLG value in the interface
`(config-if)#commit`	Commit the transaction.

RTR4

Loopback Interface

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter the Interface mode for loopback interface.
`(config-if)#ip address 4.4.4.4/32 secondary`	Configure IP address on the loopback address.
`(config-if)#commit`	Commit the transaction.

MPLS Interface

`(config)#interface xe9`	Enter the Interface mode
`(config-if)#ip address 23.1.1.4/24`	Configure ip address on the interface
`(config-if)#label-switching`	Enable label switching on the interface

(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#ip address 12.1.1.4/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#ip address 31.1.1.4/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter Router OSPF mode.
(config-router)#router-id 4.4.4.4	Configure OSPF router id
(config-router)#network 4.4.4.4/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 12.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 23.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 31.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe9	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

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SRLG Interface

(config)#interface ce50	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 31	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce52	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 12	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 23	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

RTR5

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for loopback interface.
(config-if)#ip address 5.5.5.5/32 secondary	Configure IP address on the loopback address.
(config-if)#commit	Commit the transaction.

MPLS Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#ip address 22.1.1.5/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#ip address 23.1.1.5/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 21.1.1.5/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter Router OSPF mode.
(config-router)#router-id 5.5.5.5	Configure OSPF router id
(config-router)#network 5.5.5.5/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 21.1.1.0/24 area 0	Advertise network address in OSPF.

(config-router)#network 22.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 23.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#srlg-disjoint forced	Configure SRLG path type forced
(config-router)#commit	Commit the transaction.

SRLG Interface

(config)#interface xe1	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 11	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe5	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 21	Configure SRLG value in the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface xe9	Enter the Interface mode
(config-if)#mpls traffic-eng srlg 23	Configure SRLG value in the interface
(config-if)#commit	Commit the transaction.

RTR6

Loopback Interface

#configure terminal	Enter configure mode.
(config)#interface lo	Enter the Interface mode for loopback interface.
(config-if)#ip address 6.6.6.6/32 secondary	Configure IP address on the loopback address.
(config-if)#commit	Commit the transaction.

MPLS Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#ip address 30.1.1.6/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#ip address 31.1.1.6/24	Configure ip address on the interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#commit	Commit the transaction.

OSPF

(config)#router ospf 1	Enter Router OSPF mode.
(config-router)#router-id 6.6.6.6	Configure OSPF router id
(config-router)#network 6.6.6.6/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 30.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 31.1.1.0/24 area 0	Advertise network address in OSPF.
(config-router)#commit	Commit the transaction.

Global RSVP

(config)#router rsvp	Enter the Router RSVP mode.
(config-router)#commit	Commit the transaction.

RSVP Interface

(config)#interface xe5	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#interface ce50	Enter the Interface mode
(config-if)#enable-rsvp	Enable RSVP on the interface
(config-if)#commit	Commit the transaction.

Global SRLG (Path Type: Forced)

`(config)#router rsvp`	Enter the Router RSVP mode.
`(config-router)#srlg-disjoint forced`	Configure SRLG path type forced
`(config-router)#commit`	Commit the transaction.

SRLG Interface

`(config)#interface xe5`	Enter the Interface mode
`(config-if)#mpls traffic-eng srlg 30`	Configure SRLG value in the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#interface ce50`	Enter the Interface mode
`(config-if)#mpls traffic-eng srlg 31`	Configure SRLG value in the interface
`(config-if)#commit`	Commit the transaction.

Validation

R1 Configuration (Ingress)

OSPF:

```
RTR2#show ip ospf neighbor
Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface           Instance ID
3.3.3.3           1   Full/DR          00:00:29    11.1.1.3        xe7                      0
5.5.5.5           1   Full/DR          00:00:37    22.1.1.5        xe1                      0
6.6.6.6           1   Full/DR          00:00:35    30.1.1.6        xe5                      0
```

RSVP:

```
RTR2#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary


Ingress RSVP:
To              From            Type    LSPName                         State Uptime    Rt  Style  Labelin  Labelout  DSType
4.4.4.4         2.2.2.2         PRI     lsp1-Primary                    UP    01:14:21  1 1 SE     -        24960     DEFAULT
4.4.4.4         2.2.2.2         SEC     lsp1-Secondary-Priority-1       UP    01:14:21  1 1 SE     -        24320     DEFAULT
4.4.4.4         2.2.2.2         PRI     lsp2-Primary                    UP    01:03:18  1 1 SE     -        24961     DEFAULT
4.4.4.4         30.1.1.2        DTR     lsp2-Detour                     UP    01:03:18  1 1 SE     -        24321     DEFAULT
4.4.4.4         2.2.2.2         BPS     bypass1-Bypass                  UP    00:58:02  1 1 SE     -        24962     DEFAULT
4.4.4.4         2.2.2.2         PRI     lsp3-Primary                    UP    00:57:26  1 1 SE     -        24321     DEFAULT
Total 6 displayed, Up 6, Down 0.
```

```
RTR2#show  rsvp session detail
Ingress (Primary)
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Primary
  Ingress FSM state: Operational
  Establishment Time: 0s 16ms
  SRLG configured in primary path are: 11 12
  Setup priority: 7, Hold priority: 0
```

```
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 201
  LSP Protection: None
  Label in: -,  Label out:    24960,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 11.1.1.3, xe7
  Path refresh: 30 seconds (RR enabled) (due in 25417 seconds)
  Resv lifetime: 157 seconds (due in 133 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: path1 (in use)
  Configured Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Session Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Record route:
   ------------------------------------------------------------
   IP Address        Label
   ------------------------------------------------------------
   <self>
   11.1.1.3
   12.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority1)
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Secondary-Priority-1
  Ingress FSM state: Operational
  Establishment Time: 0s 38ms
  SRLG configured in backup path are: 30 31
  SRLG-disjoint Configured: Forced
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 101
  LSP Protection: None
  Label in: -,  Label out:    24320,
```

```
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2204, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 30.1.1.6, xe5
  Path refresh: 30 seconds (RR enabled) (due in 25416 seconds)
  Resv lifetime: 157 seconds (due in 127 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: sec-path1 (in use)
  Configured Explicit Route Detail :
   4.4.4.4/32 loose
  Session Explicit Route Detail :
   30.1.1.6/32 strict
   31.1.1.4/32 strict
  Record route:
   --------------------------------------------------------------
   IP Address        Label
   --------------------------------------------------------------
   <self>
   30.1.1.6
   31.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Primary)
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp2-Primary
  Ingress FSM state: Operational
  Establishment Time: 0s 10ms
  SRLG configured in primary path are: 11 12
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 201
  LSP Protection: one-to-one
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in: -,  Label out:    24961,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
```

```
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 11.1.1.3, xe7
  Path refresh: 30 seconds (RR enabled) (due in 26088 seconds)
  Resv lifetime: 157 seconds (due in 133 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: path1 (in use)
  Configured Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Session Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Record route:
   LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
   NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
   ----------------------------------------------------------------
   IP Address        Label     (LP, PU, NP, BP)
   ----------------------------------------------------------------
   <self>
   11.1.1.3                    ( 1,  0,  0,  0)
   12.1.1.4                    ( 0,  0,  0,  0)
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Detour)
4.4.4.4
  From: 30.1.1.2, LSPstate: Up, LSPname: lsp2-Detour
  Ingress FSM state: Operational
  Establishment Time: 0s 9ms
  SRLG configured in backup path are: 30 31
  SRLG-disjoint Configured: Forced
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 101
  LSP Protection: None
  Label in: -,  Label out:    24321,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 30.1.1.6, xe5
```

```
  Path refresh: 30 seconds (RR enabled) (due in 26073 seconds)
  Resv lifetime: 157 seconds (due in 127 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Exclude path detail:
   Exclude Link: 11.1.1.3
  Configured Path: none
  Session Explicit Route Detail :
   30.1.1.6/32 strict
   31.1.1.4/32 strict
  Record route:
   --------------------------------------------------------------
   IP Address        Label
   --------------------------------------------------------------
   <self>
   30.1.1.6
   31.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Bypass)
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: bypass1-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 10ms
  SRLG configured in primary path are: 11 12
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 201
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    24962,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5003, LSP Id: 2207, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 11.1.1.3, xe7
  Path refresh: 30 seconds (RR enabled) (due in 26388 seconds)
  Resv lifetime: 157 seconds (due in 133 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
```

```
  Configured Path: path1 (in use)
  Configured Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Session Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   <self>
   11.1.1.3
   12.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
  Total LSP protected : 0, Bandwidth in use : 0
Ingress (Primary)
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp3-Primary
  Ingress FSM state: Operational
  Establishment Time: 0s 17ms
  SRLG configured in primary path are: 11 23
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 2
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in: -,  Label out:    24321,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5004, LSP Id: 2208, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 22.1.1.5, xe1
  Path refresh: 30 seconds (RR enabled) (due in 26421 seconds)
  Resv lifetime: 157 seconds (due in 141 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups: none
  Configured Path: sec-path1 (in use)
```

```
  Configured Explicit Route Detail :
   4.4.4.4/32 loose
  Session Explicit Route Detail :
   22.1.1.5/32 strict
   23.1.1.4/32 strict
  Record route:
   LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
   NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
   ---------------------------------------------------------------
   IP Address        Label     (LP, PU, NP, BP)
   ---------------------------------------------------------------
   <self>
   22.1.1.5          24321     ( 0,  0,  0,  0)
   23.1.1.4          0         ( 0,  0,  0,  0)
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

CSPF LSP:

```
RTR2#show  cspf lsp
   Lsp Id          : 0x13890899
   OSPF ID         : 1
   Ingress         : 2.2.2.2
   Egress          : 4.4.4.4
   Ext Tunnel ID   : 2.2.2.2
   LSP Type        : 0
   Client ID       : 1
   State           : 3
   Setup Priority  : 7
   Hold Priority   : 0
   Hop Limit       : 255
   Include Mask    : 0x0
   Exclude Mask    : 0x0
   Include All Mask: 0x0
   LSP Metric      : 201
   Path Constraint :
       11.1.1.3    strict
       12.1.1.4    strict
   Computed ERO    :
       11.1.1.3
       12.1.1.4

   SRLG values of LSP :
   11   12
```

```
Lsp Id           : 0x1389089c
OSPF ID          : 1
Ingress          : 2.2.2.2
Egress           : 4.4.4.4
Ext Tunnel ID    : 2.2.2.2
LSP Type         : 0
Client ID        : 1
State            : 3
Setup Priority   : 7
Hold Priority    : 0
Hop Limit        : 255
Include Mask     : 0x0
Exclude Mask     : 0x0
Include All Mask: 0x0
LSP Metric       : 101
Path Constraint :
    4.4.4.4    loose
Exclude SRLG Constraint :
11    12
Computed ERO     :
    30.1.1.6
    31.1.1.4

SRLG values of LSP :
30   31
Lsp Id           : 0x138a089e
OSPF ID          : 1
Ingress          : 2.2.2.2
Egress           : 4.4.4.4
Ext Tunnel ID    : 2.2.2.2
LSP Type         : 0
Client ID        : 1
State            : 3
Setup Priority   : 7
Hold Priority    : 0
Hop Limit        : 255
Include Mask     : 0x0
Exclude Mask     : 0x0
Include All Mask: 0x0
LSP Metric       : 201
Path Constraint :
    11.1.1.3    strict
    12.1.1.4    strict
Computed ERO     :
    11.1.1.3
    12.1.1.4

SRLG values of LSP :
11   12
Lsp Id           : 0x138a089e
```

```
OSPF ID         : 1
Ingress         : 30.1.1.2
Egress          : 4.4.4.4
Ext Tunnel ID   : 2.2.2.2
LSP Type        : 0
Client ID       : 1
State           : 3
Setup Priority  : 7
Hold Priority   : 0
Hop Limit       : 255
Include Mask    : 0x0
Exclude Mask    : 0x0
Include All Mask: 0x0
LSP Metric      : 101
Exclude Path Constraint :
    11.1.1.3    exclude link
Exclude SRLG Constraint :
11
Computed ERO    :
    30.1.1.6
    31.1.1.4

SRLG values of LSP :
30   31
Lsp Id          : 0x138b089f
OSPF ID         : 1
Ingress         : 2.2.2.2
Egress          : 4.4.4.4
Ext Tunnel ID   : 2.2.2.2
LSP Type        : 2
Client ID       : 1
State           : 3
Setup Priority  : 7
Hold Priority   : 0
Hop Limit       : 255
Include Mask    : 0x0
Exclude Mask    : 0x0
Include All Mask: 0x0
LSP Metric      : 201
Path Constraint :
    11.1.1.3    strict
    12.1.1.4    strict
Computed ERO    :
    11.1.1.3
    12.1.1.4

SRLG values of LSP :
11   12
Lsp Id          : 0x138c08a0
OSPF ID         : 1
```

```
Ingress          : 2.2.2.2
Egress           : 4.4.4.4
Ext Tunnel ID    : 2.2.2.2
LSP Type         : 0
Client ID        : 1
State            : 3
Setup Priority   : 7
Hold Priority    : 0
Hop Limit        : 255
Include Mask     : 0x0
Exclude Mask     : 0x0
Include All Mask: 0x0
LSP Metric       : 2
Path Constraint :
    4.4.4.4    loose
Computed ERO     :
    22.1.1.5
    23.1.1.4

SRLG values of LSP :
11   23
```

RTR3 Configuration (Transit)

OSPF:

```
RTR3#show  ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface           Instance ID
2.2.2.2           1   Full/Backup      00:00:32    11.1.1.2        xe7                     0
4.4.4.4           1   Full/Backup      00:00:32    12.1.1.4        ce52                    0
5.5.5.5           1   Full/Backup      00:00:36    21.1.1.5        xe5                     0
```

RSVP:

```
RTR3#show  rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Type    LSPName                          State Uptime    Rt  Style  Labelin  Labelout  DSType
4.4.4.4         21.1.1.3        DTR     lsp2-Detour                      UP    01:12:50  1 1 SE     -        24320     ELSP_CON
Total 1 displayed, Up 1, Down 0.

Transit RSVP:
To              From            Type    LSPName                          State Uptime    Rt  Style  Labelin  Labelout  DSType
4.4.4.4         2.2.2.2         PRI     lsp1-Primary                     UP    01:23:54  1 1 SE     24960    0         ELSP_CON
4.4.4.4         2.2.2.2         PRI     lsp2-Primary                     UP    01:12:50  1 1 SE     24961    0         ELSP_CON
4.4.4.4         2.2.2.2         PRI     bypass1-Bypass                   UP    01:07:35  1 1 SE     24962    0         ELSP_CON
Total 3 displayed, Up 3, Down 0.
```

```
RTR3#show  rsvp session detail
Transit
```

```
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Primary
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    24960,  Label out:        0,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 12.1.1.4, ce52   Upstream: 11.1.1.2, xe7
  Path refresh: 30 seconds (RR enabled) (due in 24976 seconds)
  Path lifetime: 157 seconds (due in 112 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 32606 seconds)
  Resv lifetime: 157 seconds (due in 143 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Session Explicit Route Detail :
   12.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   11.1.1.2
   <self>
   12.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Transit
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp2-Primary
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: one-to-one
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:    24961,  Label out:        0,
```

```
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 12.1.1.4, ce52   Upstream: 11.1.1.2, xe7
  Path refresh: 30 seconds (RR enabled) (due in 25624 seconds)
  Path lifetime: 157 seconds (due in 112 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 24416 seconds)
  Resv lifetime: 157 seconds (due in 143 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Session Explicit Route Detail :
   12.1.1.4/32 strict
  Record route:
   --------------------------------------------------------------
   IP Address        Label
   --------------------------------------------------------------
   11.1.1.2
   <self>
   12.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Detour)
4.4.4.4
  From: 21.1.1.3, LSPstate: Up, LSPname: lsp2-Detour
  Ingress FSM state: Operational
  Establishment Time: 0s 8ms
  SRLG configured in backup path are: 21 23
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 2
  LSP Protection: None
  Label in: -,  Label out:    24320,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 21.1.1.5, xe5
  Path refresh: 30 seconds (RR enabled) (due in 25636 seconds)
  Resv lifetime: 157 seconds (due in 153 seconds)
```

```
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Exclude path detail:
   Exclude Link: 11.1.1.2
   Exclude Link: 12.1.1.4
  Configured Path: none
  Session Explicit Route Detail :
   21.1.1.5/32 strict
   23.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   <self>
   21.1.1.5
   23.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Transit
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: bypass1-Bypass
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    24962,  Label out:        0,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5003, LSP Id: 2207, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 12.1.1.4, ce52   Upstream: 11.1.1.2, xe7
  Path refresh: 30 seconds (RR enabled) (due in 25940 seconds)
  Path lifetime: 157 seconds (due in 112 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 27142 seconds)
  Resv lifetime: 157 seconds (due in 143 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   11.1.1.3/32 strict
   12.1.1.4/32 strict
  Session Explicit Route Detail :
   12.1.1.4/32 strict
```

```
  Record route:
   ------------------------------------------------------------
   IP Address        Label
   ------------------------------------------------------------
   11.1.1.2
   <self>
   12.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

RTR4 Configuration (Egress)

OSPF:

```
RTR4#show  ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface          Instance ID
3.3.3.3           1   Full/DR          00:00:27    12.1.1.3        ce52                     0
5.5.5.5           1   Full/Backup      00:00:27    23.1.1.5        xe9                      0
       6.6.6.6           1   Full/Backup      00:00:34    31.1.1.6        ce50                     0
```

RSVP:

```
RTR4#show  rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Egress RSVP:
To              From            Type    LSPName                         State Uptime    Rt  Style  Labelin  Labelout  DSType
4.4.4.4         2.2.2.2         PRI     lsp1-Primary                    UP    01:28:26  1 1 SE     0        -         ELSP_CON
4.4.4.4         2.2.2.2         PRI     lsp1-Secondary-Priority-1       UP    01:28:26  1 1 SE     0        -         ELSP_CON
4.4.4.4         2.2.2.2         PRI     lsp2-Primary                    UP    01:17:22  1 1 SE     0        -         ELSP_CON
4.4.4.4         30.1.1.2        PRI     lsp2-Detour                     UP    01:17:22  1 1 SE     0        -         ELSP_CON
4.4.4.4         21.1.1.3        PRI     lsp2-Detour                     UP    01:17:22  1 1 SE     0        -         ELSP_CON
4.4.4.4         2.2.2.2         PRI     bypass1-Bypass                  UP    01:12:07  1 1 SE     0        -         ELSP_CON
4.4.4.4         2.2.2.2         PRI     lsp3-Primary                    UP    01:11:31  1 1 SE     0        -         ELSP_CON
Total 7 displayed, Up 7, Down 0.
```

```
RTR4#show  rsvp session detail
Egress
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        0,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
```

```
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 12.1.1.3, ce52
  Path lifetime: 157 seconds (due in 141 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 39085 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   12.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   11.1.1.2
   12.1.1.3
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Secondary-Priority-1
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        0,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2204, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 31.1.1.6, ce50
  Path lifetime: 157 seconds (due in 141 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 9957 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   31.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   30.1.1.2
   31.1.1.6
   <self>
```

```
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp2-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: one-to-one
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:        0,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 12.1.1.3, ce52
  Path lifetime: 157 seconds (due in 141 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 33578 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   12.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   11.1.1.2
   12.1.1.3
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
4.4.4.4
  From: 30.1.1.2, LSPstate: Up, LSPname: lsp2-Detour
```

```
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        0,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 31.1.1.6, ce50
  Path lifetime: 157 seconds (due in 141 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 27672 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   31.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   30.1.1.2
   31.1.1.6
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
4.4.4.4
  From: 21.1.1.3, LSPstate: Up, LSPname: lsp2-Detour
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        0,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 23.1.1.5, xe9
  Path lifetime: 157 seconds (due in 133 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 17352 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   23.1.1.4/32 strict
  Record route:
```

```
   --------------------------------------------------------------
   IP Address        Label
   --------------------------------------------------------------
   21.1.1.3
   23.1.1.5
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: bypass1-Bypass
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        0,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5003, LSP Id: 2207, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 12.1.1.3, ce52
  Path lifetime: 157 seconds (due in 141 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 22891 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   12.1.1.4/32 strict
  Record route:
   --------------------------------------------------------------
   IP Address        Label
   --------------------------------------------------------------
   11.1.1.2
   12.1.1.3
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
```

```
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp3-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:        0,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5004, LSP Id: 2208, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 23.1.1.5, xe9
  Path lifetime: 157 seconds (due in 133 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 33344 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups:   Received Explicit Route Detail :
   23.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   22.1.1.2          24321
   23.1.1.5          0
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

RTR5 Configuration

OSPF:

```
RTR5#show  ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface           Instance ID
3.3.3.3           1   Full/DR          00:00:34    21.1.1.3        xe5                     0
2.2.2.2           1   Full/Backup      00:00:30    22.1.1.2        xe1                     0
4.4.4.4           1   Full/DR          00:00:39    23.1.1.4        xe9                     0
```

RSVP:

```
RTR5#show  rsvp session
```

```
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
To              From            Type    LSPName                         State Uptime    Rt  Style  Labelin  Labelout  DSType
4.4.4.4         21.1.1.3        PRI     lsp2-Detour                    UP    01:23:45  1 1 SE     24320    0         ELSP_CON
4.4.4.4         2.2.2.2         PRI     lsp3-Primary                   UP    01:17:54  1 1 SE     24321    0         ELSP_CON
Total 2 displayed, Up 2, Down 0.


RTR5#show  rsvp session detail
Transit
4.4.4.4
  From: 21.1.1.3, LSPstate: Up, LSPname: lsp2-Detour
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    24320,  Label out:        0,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 23.1.1.4, xe9   Upstream: 21.1.1.3, xe5
  Path refresh: 30 seconds (RR enabled) (due in 24907 seconds)
  Path lifetime: 157 seconds (due in 126 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 36355 seconds)
  Resv lifetime: 157 seconds (due in 144 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   21.1.1.5/32 strict
   23.1.1.4/32 strict
  Session Explicit Route Detail :
   23.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   21.1.1.3
   <self>
   23.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Transit
4.4.4.4
```

```
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp3-Primary
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:    24321,  Label out:       0,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5004, LSP Id: 2208, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 23.1.1.4, xe9   Upstream: 22.1.1.2, xe1
  Path refresh: 30 seconds (RR enabled) (due in 25271 seconds)
  Path lifetime: 157 seconds (due in 148 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 38338 seconds)
  Resv lifetime: 157 seconds (due in 144 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups:   Received Explicit Route Detail :
   22.1.1.5/32 strict
   23.1.1.4/32 strict
  Session Explicit Route Detail :
   23.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   22.1.1.2          24321
   <self>
   23.1.1.4          0
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

RTR6 Configuration

OSPF:

```
RTR6#show  ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface           Instance ID
 2.2.2.2          1   Full/Backup      00:00:32    30.1.1.2        xe5                     0
 4.4.4.4          1   Full/DR          00:00:38    31.1.1.4        ce50                    0
```

RSVP:

```
RTR6#show  rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
To              From            Type    LSPName                         State Uptime    Rt  Style  Labelin  Labelout  DSType
4.4.4.4         2.2.2.2         PRI     lsp1-Secondary-Priority-1       UP    01:38:16  1 1 SE     24320    0         ELSP_CON
4.4.4.4         30.1.1.2        PRI     lsp2-Detour                     UP    01:27:12  1 1 SE     24321    0         ELSP_CON
Total 2 displayed, Up 2, Down 0.
```

```
RTR6#show  rsvp session detail
Transit
4.4.4.4
  From: 2.2.2.2, LSPstate: Up, LSPname: lsp1-Secondary-Priority-1
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    24320,  Label out:        0,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2204, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 31.1.1.4, ce50   Upstream: 30.1.1.2, xe5
  Path refresh: 30 seconds (RR enabled) (due in 24080 seconds)
  Path lifetime: 157 seconds (due in 149 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 37411 seconds)
  Resv lifetime: 157 seconds (due in 150 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   30.1.1.6/32 strict
   31.1.1.4/32 strict
  Session Explicit Route Detail :
   31.1.1.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   30.1.1.2
   <self>
   31.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
```

```
  Trunk Type: mpls
Transit
4.4.4.4
  From: 30.1.1.2, LSPstate: Up, LSPname: lsp2-Detour
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    24321,  Label out:        0,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2206, Ext-Tunnel Id: 2.2.2.2
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 31.1.1.4, ce50   Upstream: 30.1.1.2, xe5
  Path refresh: 30 seconds (RR enabled) (due in 24724 seconds)
  Path lifetime: 157 seconds (due in 149 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 32187 seconds)
  Resv lifetime: 157 seconds (due in 150 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   30.1.1.6/32 strict
   31.1.1.4/32 strict
  Session Explicit Route Detail :
   31.1.1.4/32 strict
  Record route:
   --------------------------------------------------------------
   IP Address        Label
   --------------------------------------------------------------
   30.1.1.2
   <self>
   31.1.1.4
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

CHAPTER 5 MPLS DiffServ Configuration

This chapter contains an overview of MPLS DiffServ functionality and terminology, MPLS DiffServ configuration example for a relevant scenario, configuration guidelines, and sample procedures for enabling and configuring MPLS DiffServ.

MPLS Diff-Serv Overview

The initial efforts to provide quality of service (QoS) in IP networks were based on a per application-Flow model (IntServ), in which individual applications requested QoS. With large number of flows traversing IP networks, this approach proved to be un-scalable and overly complex, and a more “coarse-grained” model was developed in the form of DiffServ. DiffServ approaches the problem of QoS by dividing traffic into a small number of classes and allocating network resources on a per-class basis. DiffServ provides differential forwarding treatment to traffic, thus enforcing QoS for different traffic flows. It is a scalable solution that does not require per flow signalling and state maintenance in the core. However, it cannot guarantee QoS if the path followed by the traffic does not have adequate resources to meet the QoS requirements.

DiffServ Tunnelling modes:

RFC 3270 has recommended three QoS models for DiffServ tunnelled traffic in MPLS networks:

OcNOS supports two models:

- Pipe model (default mode): With the Pipe Model, MPLS tunnels (aka LSPs) are used to hide the intermediate MPLS nodes between LSP Ingress and Egress from the Diff-Serv perspective. In this model, tunneled packets must convey two meaningful pieces of Diff-Serv information:
  - The Diff-Serv information which is meaningful to intermediate nodes along the LSP span including the LSP Egress (which we refer to as the “LSP Diff-Serv Information”).This LSP Diff-Serv Information is not meaningful beyond the LSP Egress: Whether Traffic Conditioning at intermediate nodes on the LSP span affects the LSP Diff-Serv information or not, this updated Diff-Serv information is not considered meaningful beyond the LSP Egress and is ignored.
  - The Diff-Serv information which is meaningful beyond the LSP Egress (which we refer to as the “Tunneled Diff-Serv Information”).This information is to be conveyed by the LSP Ingress to the LSP Egress.This Diff-Serv information is not meaningful to the intermediate nodes on the LSP span.
- Uniform model: With the Uniform Model, MPLS tunnels (aka LSPs) are viewed as artifacts of the end-to-end path from the Diff-Serv standpoint. MPLS Tunnels may be used for forwarding purposes but have no significant impact on Diff-Serv. In this model, any packet contains exactly one piece of Diff-Serv information which is meaningful and is always encoded in the outer most label entry (or in the IP DSCP where the IP packet is transmitted unlabeled for instance at the egress of the LSP). Any Diff-Serv information encoded somewhere else (e.g., in deeper label entries) is of no significance to intermediate nodes or to the tunnel egress and is ignored. If Traffic Conditioning at intermediate nodes on the LSP span affects the “outer” Diff-Serv information, the updated Diff-Serv information is the one considered meaningful at the egress of the LSP.
  - The Uniform Model for Diff-Serv over MPLS is such that, from the Diff-Serv perspective, operations are exactly identical to the operations if MPLS was not used. In other words, MPLS is entirely transparent to the Diff-Serv operations.
  - Use of the Uniform Model allows LSPs to span Diff-Serv domain boundaries without any other measure in place than an inter-domain Traffic Conditioning Agreement at the physical boundary between the Diff-Serv domains and operating exclusively on the “outer” header, since the meaningful Diff-Serv information is always visible and modifiable in the outmost label entry.

Terminology

Following is a brief description of terms and concepts used to describe MPLS Diffserv.

EXP Value

The MPLS experimental bits (EXP) field is a 3-bit field in the MPLS header that you can use to define the QoS treatment (per-hop behavior) that a node should give to a packet. In an IP network, the DiffServ Code Point (DSCP) (a 6-bit field) defines a class and drop precedence. The EXP bits can be used to carry some of the information encoded in the IP DSCP and can also be used to encode the dropping precedence.

By default, OcNOS copies the three most significant bits of the DSCP or the IP precedence of the IP packet to the EXP field in the MPLS header. This action happens when the MPLS header is initially imposed on the IP packet. However, you can also set the EXP field by defining a mapping between the DSCP or IP precedence and the EXP bits. This mapping is configured using the set mpls class command in pmap-class mode or qos map class exp in global mode. For more information, see the “Remarking” section.

DSCP Value

Differentiated Services Code Point (DSCP) is a 6-bit value used to classify the priority of Layer-3 packets upon entry into a network. DSCP values range from 0 to 63, 63 being the highest priority, 0 being best-effort traffic.

Classification

Traffic classification allows the network to recognize traffic as it falls into classes that you have configured. Network traffic must be classified to apply specific QoS to it. Classification can be inclusive (for example, all of the traffic passing through an interface) or classification can be very specific (for example, you can use a class map with match commands that recognize specific aspects of the traffic). You can classify and apply QoS (for example, marking) and then, on another interface or network device, classify again based on the marked value and apply other QoS.

Policing

Policing determines whether a packet is in or out of profile by comparing the internal DSCP to the configured policer. Policer limits the bandwidth consumed by a traffic flow with the results given to the marker.

Policing and policers have the following attributes:

- Policers can occur only on a physical port basis.
- Policing can occur on ingress interfaces.
- Only one policer can be applied to a packet per direction.

Marking

Marking determines how to handle a packet when it is out of profile. It assesses the policer and the configuration data to determine the action required for the packet, and then handles the packet using one of the following methods:

- Let the packet through without modification
- Drop the packet

Marking can occur on ingress and egress interfaces.

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Class Map

A class map names and isolates specific traffic from other traffic. The class map defines the criteria used to match against a specific traffic flow to classify it further. The criteria can include:

- Matching the access group defined by the ACL
- Matching a specific list of DSCP values

If there is more than one type of traffic to be classified, another class map can be created under a different name. After a packet is matched against the class-map criteria, it is further classified using a policy map.

Policy Map

A policy map specifies on which traffic class to act. This can be implemented as follows:

- Set a specific CoS or DSCP value in the traffic class.
- Specify the traffic bandwidth limitations for each matched traffic class (policer) and the action to take (marking) when the traffic is out of profile.

Policy maps have the following attributes:

- A policy map can contain multiple class statements, each with different match criteria and policers.
- A separate policy-map class can exist for each type of traffic received through an interface.
- There can be only one policy map per interface per direction. The same policy map can be applied to multiple interfaces and directions.
- Before a policy map can be effective, it must be attached to an interface.

MPLS Class

MPLS class or class specifies the class of the frames, for example frames with DSCP 0-7 belongs to class 0, DSCP 8-15 belongs to Class 1, and so on.

In OcNOS, there are 8 classes varying form 0-7. By default, EXP to class is mapped one-to-one.

For more, see Table 5-1

For MPLS Diff-Serv to work, QoS must be enabled at the global level. By default QoS is disabled.

Table 5-1: EXP to class mapping

CoS	DSCP	EXP	Class	Queue
0	0-7	0	0	0
1	8-15	1	1	1
2	16-23	2	2	2
3	24-31	3	3	3
4	32-39	4	4	4
5	40-47	5	5	5
6	48-55	6	6	6
7	56-63	7	7	7

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CHAPTER 6 Remarking Configuration

This chapter contains a complete sample of configuring marking on global level and remarking of EXP bits on interface and global level along with LDP LSP for Pipe model and Uniform model.

Configuration

Configuring Remarking for MPLS EXP bits require following configurations:

- Enabling label-switching on the interface on NSM.
- Configuring LSP (Using LDP, Static or RSVP-TE, in this example we are using LDP for setting up LSP).
- Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
- Enable QoS, Configuring Remarking on interface and Global Level.

Topology

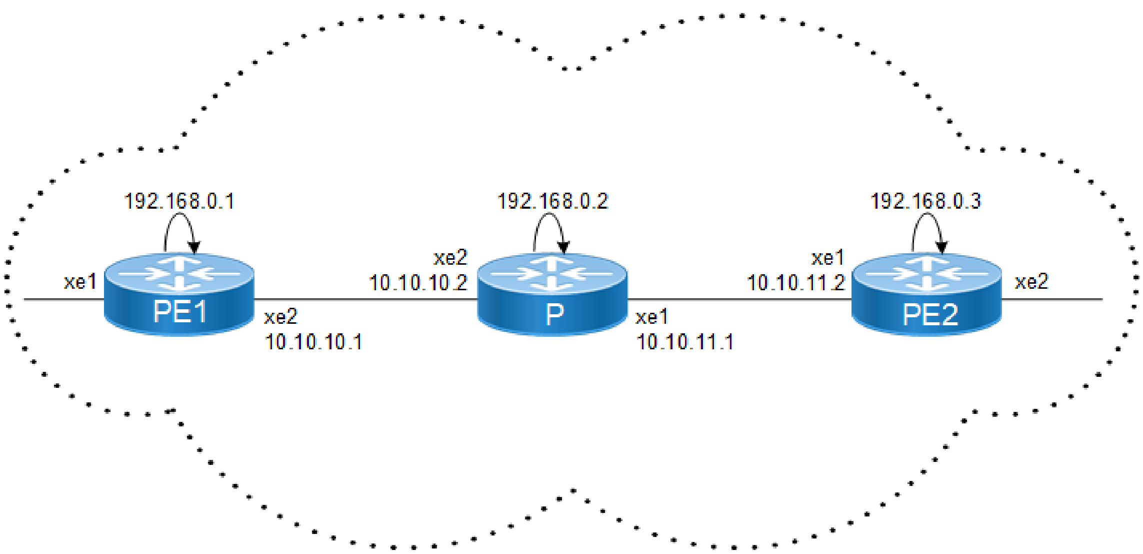

Figure 6-2: Basic LDP Topology

OSPF and LDP Configuration for PE1, P and PE2

PE1: NSM

`#configure terminal`	Enter configure mode.
`(config)#interface xe2`	Specify the interface `(xe2)` to be configured.
`(config-if)#ip address 10.10.10.1/24`	Configure IP address for the interface
`(config-if)#label-switching`	Enable label switching on interface `xe2`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback (`lo`) interface to be configured.

(config-if)#ip address 192.168.0.1/32 secondary	Set the IP address of the loopback interface to 192.168.0.1/32
(config-if)#commit	Commit the transaction.

PE1: OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 192.168.0.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE1: LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.1	Set the router ID to IP address 192.168.0.1.
(config-router)#transport-address ipv4 192.168.0.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#commit	Commit the transaction.

P: NSM

#configure terminal	Enter configure mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.10.2/24	Configure IP address for the interface
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.11.1/24	Configure IP address for the interface
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.2/32 secondary	Set the IP address of the loopback interface to 192.168.0.2/32
(config-if)#commit	Commit the transaction.

P: OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

`(config-router)#network 10.10.10.0/24 area 0`
`(config-router)#network 10.10.11.0/24 area 0`
`(config-router)#network 192.168.0.2/32 area 0`
	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

`(config-router)#commit`	Commit the transaction.

P: LDP

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter Router mode for LDP.
`(config-router)#router-id 192.168.0.2`	Set the router ID to IP address 192.168.0.2.
`(config-router)#transport-address ipv4 192.168.0.2`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
`(config-router)#exit`	Exit router mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on xe1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on xe2.
`(config-if)#commit`	Commit the transaction.

PE2: NSM

`#configure terminal`	Enter configure mode.
`(config)#interface xe1`	Specify the interface `(xe2)` to be configured.
`(config-if)#ip address 10.10.11.2/24`	Configure IP address for the interface
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback (`lo`) interface to be configured.
`(config-if)#ip address 192.168.0.3/32 secondary`	`Set the IP address of the loopback interface to 192.168.0.3/32`
`(config-if)#commit`	Commit the transaction.

PE2: OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 10.10.11.0/24 area 0` `(config-router)#network 192.168.0.3/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.

PE2: LDP

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter Router mode for LDP.
`(config-router)#router-id 192.168.0.3`	Set the router ID to IP address 192.168.0.3.
`(config-router)#explicit-null`	To disable PHP.
`(config-router)#transport-address ipv4 192.168.0.3`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
`(config-router)#exit`	Exit `router` mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on xe2.
`(config-if)#commit`	Commit the transaction.

Configuration of Marking or Remarking

Marking can be done in Global level and Remarking can be done in Global level and in Interface level. Both methods are shown in the following sample configurations.

Global level configuration for PE1

`#configure terminal`	Enter configure mode.
`(config)#qos enable`	Enable QOS.
`(config)#qos profile exp-encap default`	Configure default profile.
`(config-egress-exp-encap-map)#l3 dscp 10 exp 3`	Map dscp value 10 to exp 3.
`(config-egress-exp-encap-map)#commit`	Commit the transaction.

Validation

```
PE1#show qos-profile type exp-encap default
profile name: default
```

```
profile type: exp-encap
configured mapping:
qos profile exp-encap default
 l3 dscp 10 exp 3
!
Detailed mapping:
 L3 DSCP to EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT
 -------|-------- | -------|-------- | -------|-------- | -------|--------
  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
  0       0       |  16      2       |  32      4       |  48      6
  1       0       |  17      2       |  33      4       |  49      6
  2       0       |  18      2       |  34      4       |  50      6
  3       0       |  19      2       |  35      4       |  51      6
  4       0       |  20      2       |  36      4       |  52      6
  5       0       |  21      2       |  37      4       |  53      6
  6       0       |  22      2       |  38      4       |  54      6
  7       0       |  23      2       |  39      4       |  55      6
  8       1       |  24      3       |  40      5       |  56      7
  9       1       |  25      3       |  41      5       |  57      7
  10      3       |  26      3       |  42      5       |  58      7
  11      1       |  27      3       |  43      5       |  59      7
  12      1       |  28      3       |  44      5       |  60      7
  13      1       |  29      3       |  45      5       |  61      7
  14      1       |  30      3       |  46      5       |  62      7
  15      1       |  31      3       |  47      5       |  63      7

 L2 Queue + Color to EXP
 ----------------+-------- | ----------------+-------- | ----------------+----
----
      INPUT      | OUTPUT  |       INPUT      | OUTPUT  |       INPUT      |
OUTPUT
 ----------------+-------- | ----------------+-------- | ----------------+----
----
  Queue | Color  | EXP     |  Queue | Color  | EXP     |  Queue | Color  | EXP
 -------+--------+-------- | -------+--------+-------- | -------+--------+----
----
  0       green    0       |  0       yellow   0       |  0       red      0
  1       green    1       |  1       yellow   1       |  1       red      1
  2       green    2       |  2       yellow   2       |  2       red      2
  3       green    3       |  3       yellow   3       |  3       red      3
  4       green    4       |  4       yellow   4       |  4       red      4
  5       green    5       |  5       yellow   5       |  5       red      5
  6       green    6       |  6       yellow   6       |  6       red      6
  7       green    7       |  7       yellow   7       |  7       red      7
```

Interface level configuration for PE1

`#configure terminal`	Enter configure mode.
`(config)#qos enable`	Enable QOS.
`(config)#qos profile exp-encap TEST1`	Configure non-default profile.
`(config-egress-exp-encap-map)#l3 dscp 5 exp 5`	Map dscp value 5 to exp 5.

`(config-egress-exp-encap-map)#exit`	Exit exp-encap profile mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#qos map-profile exp-encap TEST1`	Mapping qos profile to interface
`(config-if)#commit`	Commit the transaction.

Validation

```
PE1#show qos-profile type exp-encap TEST1
profile name: TEST1
profile type: exp-encap
profile attached to 1 instances
configured mapping:
 l3 dscp 5 exp 5
Detailed mapping:
 L3 DSCP to EXP
 -------+--------  |  -------+--------  |  -------+--------  |  -------+--------
  INPUT | OUTPUT   |   INPUT | OUTPUT   |   INPUT | OUTPUT   |   INPUT | OUTPUT
 -------|--------  |  -------|--------  |  -------|--------  |  -------|--------
  DSCP  | EXP      |   DSCP  | EXP      |   DSCP  | EXP      |   DSCP  | EXP
 -------+--------  |  -------+--------  |  -------+--------  |  -------+--------
  0       0        |   16      2        |   32      4        |   48      6
  1       0        |   17      2        |   33      4        |   49      6
  2       0        |   18      2        |   34      4        |   50      6
  3       0        |   19      2        |   35      4        |   51      6
  4       0        |   20      2        |   36      4        |   52      6
  5       5        |   21      2        |   37      4        |   53      6
  6       0        |   22      2        |   38      4        |   54      6
  7       0        |   23      2        |   39      4        |   55      6
  8       1        |   24      3        |   40      5        |   56      7
  9       1        |   25      3        |   41      5        |   57      7
  10      1        |   26      3        |   42      5        |   58      7
  11      1        |   27      3        |   43      5        |   59      7
  12      1        |   28      3        |   44      5        |   60      7
  13      1        |   29      3        |   45      5        |   61      7
  14      1        |   30      3        |   46      5        |   62      7
  15      1        |   31      3        |   47      5        |   63      7

 L2 Queue + Color to EXP
 ----------------+--------  |  ----------------+--------  |  ----------------+----
----
      INPUT      | OUTPUT   |        INPUT      | OUTPUT   |        INPUT      |
OUTPUT
 ----------------+--------  |  ----------------+--------  |  ----------------+----
----
  Queue | Color  | EXP      |   Queue | Color  | EXP      |   Queue | Color  | EXP
 -------+--------+--------  |  -------+--------+--------  |  -------+--------+----
----
  0       green    0        |   0       yellow   0        |   0       red      0
  1       green    1        |   1       yellow   1        |   1       red      1
  2       green    2        |   2       yellow   2        |   2       red      2
  3       green    3        |   3       yellow   3        |   3       red      3
  4       green    4        |   4       yellow   4        |   4       red      4
  5       green    5        |   5       yellow   5        |   5       red      5
  6       green    6        |   6       yellow   6        |   6       red      6
  7       green    7        |   7       yellow   7        |   7       red      7
```

Global level configuration for PE2

`#configure terminal`	Enter configure mode.
`(config)#qos enable`	Enable QOS.
`(config)#qos statistics`	Enable QOS statistics.
`(config)#qos profile exp-to-queue default`	Configure default profile
`(config-ingress-exp-queue-map)#exp 5 queue 7`	Map exp value 5 to Class 7.
`(config-ingress-exp-queue-map)#commit`	Commit the transaction.

Validation

PE2

```
PE2#show qos-profile type exp-to-queue

profile name: default
profile type: exp-to-queue
configured mapping:
qos profile exp-to-queue default
 exp 5 queue 7
!
Detailed mapping:
 -------+-----------------
  INPUT |     OUTPUT
 -------+-----------------
  EXP   | Queue  | Color
 -------+--------+--------
  0       0        green
  1       1        green
  2       2        green
  3       3        green
  4       4        green
  5       7        green
  6       6        green
  7       7        green
```

PE1

```
PE1#show qos-profile interface xe2
profile name: default
 profile type: dscp-to-queue (Ingress)
 mapping:
 --------+--------------------------- | --------+--------------------------- | -
------+-------------------------- | -------+---
------------------------
  INPUT |        OUTPUT               |  INPUT |         OUTPUT              |
INPUT |        OUTPUT               |  INPUT |
      OUTPUT
 --------+--------------------------- | --------+--------------------------- | -
------+-------------------------- | -------+---
------------------------
  DSCP   |   TC   | Color   | Out DSCP   |  DSCP   |   TC   | Color   | Out DSCP   |
DSCP  |   TC   | Color   | Out DSCP   |  DSCP  |
```

```
TC  | Color  | Out DSCP
 -------+-------+--------+---------- | -------+-------+--------+---------- | -
------+-------+--------+---------- | -------+---
----+--------+----------
   0      0       green     0        |  16      2       green    16         |
32     4      green    32        |  48      6
      green    48
   1      0       green     1        |  17      2       green    17         |
33     4      green    33        |  49      6
      green    49
   2      0       green     2        |  18      2       green    18         |
34     4      green    34        |  50      6
      green    50
   3      0       green     3        |  19      2       green    19         |
35     4      green    35        |  51      6
      green    51
   4      0       green     4        |  20      2       yellow   20         |
36     4      yellow   36        |  52      6
      green    52
   5      0       green     5        |  21      2       green    21         |
37     4      green    37        |  53      6
      green    53
   6      0       green     6        |  22      2       yellow   22         |
38     4      yellow   38        |  54      6
      green    54
   7      0       green     7        |  23      2       green    23         |
39     4      green    39        |  55      6
      green    55
   8      1       green     8        |  24      3       green    24         |
40     5      green    40        |  56      7
      green    56
   9      1       green     9        |  25      3       green    25         |
41     5      green    41        |  57      7
      green    57
  10      1       green    10        |  26      3       green    26         |
42     5      green    42        |  58      7
      green    58
  11      1       green    11        |  27      3       green    27         |
43     5      green    43        |  59      7
      green    59
  12      1       yellow   12        |  28      3       yellow   28         |
44     5      green    44        |  60      7
      green    60
  13      1       green    13        |  29      3       green    29         |
45     5      green    45        |  61      7
      green    61
  14      1       yellow   14        |  30      3       yellow   30         |
46     5      green    46        |  62      7
      green    62
  15      1       green    15        |  31      3       green    31         |
47     5      green    47        |  63      7
      green    63

profile name: default
 profile type: dscp-to-dscp (Egress)
 Status: Inactive
mapping:
 ----------------+---------- | ----------------+---------- | ----------------
+----------
```

```
      INPUT       |  OUTPUT   |       INPUT       |  OUTPUT   |       INPUT       |
OUTPUT
 ----------------+---------- | ----------------+---------- | ----------------
+----------
  DSCP |  Color   | Out DSCP  |  DSCP |  Color   | Out DSCP  |  DSCP |  Color   |
Out DSCP
 ------+---------+---------- | ------+---------+---------- | ------+---------
+----------
   0     green      0         |   0     yellow     0         |   0     red
0
   1     green      1         |   1     yellow     1         |   1     red
1
   2     green      2         |   2     yellow     2         |   2     red
2
   3     green      3         |   3     yellow     3         |   3     red
3
   4     green      4         |   4     yellow     4         |   4     red
4
   5     green      5         |   5     yellow     5         |   5     red
5
   6     green      6         |   6     yellow     6         |   6     red
6
   7     green      7         |   7     yellow     7         |   7     red
7
   8     green      8         |   8     yellow     8         |   8     red
8
   9     green      9         |   9     yellow     9         |   9     red
9
  10     green     10         |  10     yellow    12         |  10     red
14
  11     green     11         |  11     yellow    11         |  11     red
11
  12     green     12         |  12     yellow    12         |  12     red
14
  13     green     13         |  13     yellow    13         |  13     red
13
  14     green     14         |  14     yellow    14         |  14     red
14
  15     green     15         |  15     yellow    15         |  15     red
15
  16     green     16         |  16     yellow    16         |  16     red
16
  17     green     17         |  17     yellow    17         |  17     red
17
  18     green     18         |  18     yellow    20         |  18     red
22
  19     green     19         |  19     yellow    19         |  19     red
19
  20     green     20         |  20     yellow    20         |  20     red
22
  21     green     21         |  21     yellow    21         |  21     red
21
  22     green     22         |  22     yellow    22         |  22     red
22
  23     green     23         |  23     yellow    23         |  23     red
23
  24     green     24         |  24     yellow    24         |  24     red
24
  25     green     25         |  25     yellow    25         |  25     red
25
  26     green     26         |  26     yellow    28         |  26     red
30
```

```
   27      green      27         |  27      yellow     27         |  27      red
 27
   28      green      28         |  28      yellow     28         |  28      red
 30
   29      green      29         |  29      yellow     29         |  29      red
 29
   30      green      30         |  30      yellow     30         |  30      red
 30
   31      green      31         |  31      yellow     31         |  31      red
 31
   32      green      32         |  32      yellow     32         |  32      red
 32
   33      green      33         |  33      yellow     33         |  33      red
 33
   34      green      34         |  34      yellow     36         |  34      red
 38
   35      green      35         |  35      yellow     35         |  35      red
 35
   36      green      36         |  36      yellow     36         |  36      red
 38
   37      green      37         |  37      yellow     37         |  37      red
 37
   38      green      38         |  38      yellow     38         |  38      red
 38
   39      green      39         |  39      yellow     39         |  39      red
 39
   40      green      40         |  40      yellow     40         |  40      red
 40
   41      green      41         |  41      yellow     41         |  41      red
 41
   42      green      42         |  42      yellow     42         |  42      red
 42
   43      green      43         |  43      yellow     43         |  43      red
 43
   44      green      44         |  44      yellow     44         |  44      red
 44
   45      green      45         |  45      yellow     45         |  45      red
 45
   46      green      46         |  46      yellow     46         |  46      red
 46
   47      green      47         |  47      yellow     47         |  47      red
 47
   48      green      48         |  48      yellow     48         |  48      red
 48
   49      green      49         |  49      yellow     49         |  49      red
 49
   50      green      50         |  50      yellow     50         |  50      red
 50
   51      green      51         |  51      yellow     51         |  51      red
 51
   52      green      52         |  52      yellow     52         |  52      red
 52
   53      green      53         |  53      yellow     53         |  53      red
 53
   54      green      54         |  54      yellow     54         |  54      red
 54
   55      green      55         |  55      yellow     55         |  55      red
 55
   56      green      56         |  56      yellow     56         |  56      red
 56
   57      green      57         |  57      yellow     57         |  57      red
 57
```

```
  58     green     58        |  58     yellow    58        |  58     red
58
  59     green     59        |  59     yellow    59        |  59     red
59
  60     green     60        |  60     yellow    60        |  60     red
60
  61     green     61        |  61     yellow    61        |  61     red
61
  62     green     62        |  62     yellow    62        |  62     red
62
  63     green     63        |  63     yellow    63        |  63     red
63

profile name: default
 profile type: exp-to-queue (Ingress)
 mapping:
 -------+-----------------
  INPUT |     OUTPUT
 -------+-----------------
  EXP   |   TC   | Color
 -------+--------+--------
  0       0        green
  1       1        green
  2       2        green
  3       3        green
  4       4        green
  5       5        green
  6       6        green
  7       7        green

profile name: TEST1
 profile type: exp-encap (Egress)
 mapping:
 L3 DSCP to EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT
 -------|-------- | -------|-------- | -------|-------- | -------|--------
  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
   0      0       |  16      2       |  32      4       |  48      6
   1      0       |  17      2       |  33      4       |  49      6
   2      0       |  18      2       |  34      4       |  50      6
   3      0       |  19      2       |  35      4       |  51      6
   4      0       |  20      2       |  36      4       |  52      6
   5      5       |  21      2       |  37      4       |  53      6
   6      0       |  22      2       |  38      4       |  54      6
   7      0       |  23      2       |  39      4       |  55      6
   8      1       |  24      3       |  40      5       |  56      7
   9      1       |  25      3       |  41      5       |  57      7
  10      1       |  26      3       |  42      5       |  58      7
  11      1       |  27      3       |  43      5       |  59      7
  12      1       |  28      3       |  44      5       |  60      7
  13      1       |  29      3       |  45      5       |  61      7
  14      1       |  30      3       |  46      5       |  62      7
  15      1       |  31      3       |  47      5       |  63      7

 L2 Traffic-Class + Color to EXP
```

```
 ----------------+-------- | ----------------+-------- | ----------------+----
----
      INPUT      | OUTPUT  |       INPUT      | OUTPUT  |       INPUT      |
OUTPUT
 ----------------+-------- | ----------------+-------- | ----------------+----
----
    TC  | Color  | EXP     |    TC  | Color  | EXP     |    TC  | Color  | EXP
 -------+--------+-------- | -------+--------+-------- | -------+--------+----
----
  0       green    0       |  0       yellow   0       |  0       red      0
  1       green    1       |  1       yellow   1       |  1       red      1
  2       green    2       |  2       yellow   2       |  2       red      2
  3       green    3       |  3       yellow   3       |  3       red      3
  4       green    4       |  4       yellow   4       |  4       red      4
  5       green    5       |  5       yellow   5       |  5       red      5
  6       green    6       |  6       yellow   6       |  6       red      6
  7       green    7       |  7       yellow   7       |  7       red      7

PE1#show qos TEST1
profile name: TEST1
profile type: exp-encap
profile attached to 1 instances
configured mapping:
 l3 dscp 5 exp 5
Detailed mapping:
 L3 DSCP to EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT
 -------|-------- | -------|-------- | -------|-------- | -------|--------
  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
   0      0       |  16      2       |  32      4       |  48      6
   1      0       |  17      2       |  33      4       |  49      6
   2      0       |  18      2       |  34      4       |  50      6
   3      0       |  19      2       |  35      4       |  51      6
   4      0       |  20      2       |  36      4       |  52      6
   5      5       |  21      2       |  37      4       |  53      6
   6      0       |  22      2       |  38      4       |  54      6
   7      0       |  23      2       |  39      4       |  55      6
   8      1       |  24      3       |  40      5       |  56      7
   9      1       |  25      3       |  41      5       |  57      7
  10      1       |  26      3       |  42      5       |  58      7
  11      1       |  27      3       |  43      5       |  59      7
  12      1       |  28      3       |  44      5       |  60      7
  13      1       |  29      3       |  45      5       |  61      7
  14      1       |  30      3       |  46      5       |  62      7
  15      1       |  31      3       |  47      5       |  63      7

 L2 Traffic-Class + Color to EXP
 ----------------+-------- | ----------------+-------- | ----------------+----
----
      INPUT      | OUTPUT  |       INPUT      | OUTPUT  |       INPUT      |
OUTPUT
 ----------------+-------- | ----------------+-------- | ----------------+----
----
    TC  | Color  | EXP     |    TC  | Color  | EXP     |    TC  | Color  | EXP
 -------+--------+-------- | -------+--------+-------- | -------+--------+----
----
```

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```
  0       green    0       |  0       yellow   0       |  0       red      0
  1       green    1       |  1       yellow   1       |  1       red      1
  2       green    2       |  2       yellow   2       |  2       red      2
  3       green    3       |  3       yellow   3       |  3       red      3
  4       green    4       |  4       yellow   4       |  4       red      4
  5       green    5       |  5       yellow   5       |  5       red      5
  6       green    6       |  6       yellow   6       |  6       red      6
  7       green    7       |  7       yellow   7       |  7       red      7
```

PE2

```
PE2#show qos int xe1
profile name: default
 profile type: dscp-to-queue (Ingress)
 mapping:
 -------+-------------------------- | -------+-------------------------- | -
------+-------------------------- | -------+---
------------------------
  INPUT |         OUTPUT            |  INPUT |         OUTPUT            |
INPUT |         OUTPUT            |  INPUT |
      OUTPUT
 -------+-------------------------- | -------+-------------------------- | -
------+-------------------------- | -------+---
------------------------
  DSCP  |   TC  | Color  | Out DSCP  |  DSCP  |   TC  | Color  | Out DSCP  |
DSCP  |   TC  | Color  | Out DSCP  |  DSCP  |
TC  | Color  | Out DSCP
 -------+-------+--------+---------- | -------+-------+--------+---------- | -
------+-------+--------+---------- | -------+---
----+--------+----------
   0      0       green     0        |  16      2       green    16         |
32      4       green    32         |  48      6
      green    48
   1      0       green     1        |  17      2       green    17         |
33      4       green    33         |  49      6
      green    49
   2      0       green     2        |  18      2       green    18         |
34      4       green    34         |  50      6
      green    50
   3      0       green     3        |  19      2       green    19         |
35      4       green    35         |  51      6
      green    51
   4      0       green     4        |  20      2       yellow   20         |
36      4       yellow   36         |  52      6
      green    52
   5      0       green     5        |  21      2       green    21         |
37      4       green    37         |  53      6
      green    53
   6      0       green     6        |  22      2       yellow   22         |
38      4       yellow   38         |  54      6
      green    54
   7      0       green     7        |  23      2       green    23         |
39      4       green    39         |  55      6
      green    55
   8      1       green     8        |  24      3       green    24         |
40      5       green    40         |  56      7
      green    56
   9      1       green     9        |  25      3       green    25         |
41      5       green    41         |  57      7
```

```
      green    57
  10      1       green   10         |  26      3       green    26         |
42      5       green    42        |  58      7
      green    58
  11      1       green   11         |  27      3       green    27         |
43      5       green    43        |  59      7
      green    59
  12      1       yellow   12        |  28      3       yellow   28         |
44      5       green    44        |  60      7
      green    60
  13      1       green   13         |  29      3       green    29         |
45      5       green    45        |  61      7
      green    61
  14      1       yellow   14        |  30      3       yellow   30         |
46      5       green    46        |  62      7
      green    62
  15      1       green   15         |  31      3       green    31         |
47      5       green    47        |  63      7
      green    63

profile name: default
 profile type: dscp-to-dscp (Egress)
 Status: Inactive
mapping:
 ----------------+---------- | ----------------+---------- | ----------------
+----------
      INPUT      |  OUTPUT   |      INPUT      |  OUTPUT   |      INPUT      |
OUTPUT
 ----------------+---------- | ----------------+---------- | ----------------
+----------
  DSCP |  Color  | Out DSCP  |  DSCP |  Color  | Out DSCP  |  DSCP |  Color  |
Out DSCP
 ------+---------+---------- | ------+---------+---------- | ------+---------
+----------
   0     green      0        |   0     yellow     0        |   0     red
0
   1     green      1        |   1     yellow     1        |   1     red
1
   2     green      2        |   2     yellow     2        |   2     red
2
   3     green      3        |   3     yellow     3        |   3     red
3
   4     green      4        |   4     yellow     4        |   4     red
4
   5     green      5        |   5     yellow     5        |   5     red
5
   6     green      6        |   6     yellow     6        |   6     red
6
   7     green      7        |   7     yellow     7        |   7     red
7
   8     green      8        |   8     yellow     8        |   8     red
8
   9     green      9        |   9     yellow     9        |   9     red
9
  10     green     10        |  10     yellow    12        |  10     red
14
  11     green     11        |  11     yellow    11        |  11     red
11
  12     green     12        |  12     yellow    12        |  12     red
14
```

```
  13      green      13           |  13      yellow     13           |  13      red
13
  14      green      14           |  14      yellow     14           |  14      red
14
  15      green      15           |  15      yellow     15           |  15      red
15
  16      green      16           |  16      yellow     16           |  16      red
16
  17      green      17           |  17      yellow     17           |  17      red
17
  18      green      18           |  18      yellow     20           |  18      red
22
  19      green      19           |  19      yellow     19           |  19      red
19
  20      green      20           |  20      yellow     20           |  20      red
22
  21      green      21           |  21      yellow     21           |  21      red
21
  22      green      22           |  22      yellow     22           |  22      red
22
  23      green      23           |  23      yellow     23           |  23      red
23
  24      green      24           |  24      yellow     24           |  24      red
24
  25      green      25           |  25      yellow     25           |  25      red
25
  26      green      26           |  26      yellow     28           |  26      red
30
  27      green      27           |  27      yellow     27           |  27      red
27
  28      green      28           |  28      yellow     28           |  28      red
30
  29      green      29           |  29      yellow     29           |  29      red
29
  30      green      30           |  30      yellow     30           |  30      red
30
  31      green      31           |  31      yellow     31           |  31      red
31
  32      green      32           |  32      yellow     32           |  32      red
32
  33      green      33           |  33      yellow     33           |  33      red
33
  34      green      34           |  34      yellow     36           |  34      red
38
  35      green      35           |  35      yellow     35           |  35      red
35
  36      green      36           |  36      yellow     36           |  36      red
38
  37      green      37           |  37      yellow     37           |  37      red
37
  38      green      38           |  38      yellow     38           |  38      red
38
  39      green      39           |  39      yellow     39           |  39      red
39
  40      green      40           |  40      yellow     40           |  40      red
40
  41      green      41           |  41      yellow     41           |  41      red
41
  42      green      42           |  42      yellow     42           |  42      red
42
  43      green      43           |  43      yellow     43           |  43      red
43
```

```
  44      green     44        |  44     yellow    44        |  44     red
44
  45      green     45        |  45     yellow    45        |  45     red
45
  46      green     46        |  46     yellow    46        |  46     red
46
  47      green     47        |  47     yellow    47        |  47     red
47
  48      green     48        |  48     yellow    48        |  48     red
48
  49      green     49        |  49     yellow    49        |  49     red
49
  50      green     50        |  50     yellow    50        |  50     red
50
  51      green     51        |  51     yellow    51        |  51     red
51
  52      green     52        |  52     yellow    52        |  52     red
52
  53      green     53        |  53     yellow    53        |  53     red
53
  54      green     54        |  54     yellow    54        |  54     red
54
  55      green     55        |  55     yellow    55        |  55     red
55
  56      green     56        |  56     yellow    56        |  56     red
56
  57      green     57        |  57     yellow    57        |  57     red
57
  58      green     58        |  58     yellow    58        |  58     red
58
  59      green     59        |  59     yellow    59        |  59     red
59
  60      green     60        |  60     yellow    60        |  60     red
60
  61      green     61        |  61     yellow    61        |  61     red
61
  62      green     62        |  62     yellow    62        |  62     red
62
  63      green     63        |  63     yellow    63        |  63     red
63

profile name: default
 profile type: exp-to-queue (Ingress)
 mapping:
 -------+-----------------
  INPUT |     OUTPUT
 -------+-----------------
  EXP   |   TC   | Color
 -------+--------+--------
  0       0        green
  1       1        green
  2       2        green
  3       3        green
  4       4        green
  5       7        green
  6       6        green
  7       7        green

profile name: default
 profile type: exp-encap (Egress)
```

```
 mapping:
 L3 DSCP to EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT
 -------|-------- | -------|-------- | -------|-------- | -------|--------
  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
   0      0       |  16      2       |  32      4       |  48      6
   1      0       |  17      2       |  33      4       |  49      6
   2      0       |  18      2       |  34      4       |  50      6
   3      0       |  19      2       |  35      4       |  51      6
   4      0       |  20      2       |  36      4       |  52      6
   5      0       |  21      2       |  37      4       |  53      6
   6      0       |  22      2       |  38      4       |  54      6
   7      0       |  23      2       |  39      4       |  55      6
   8      1       |  24      3       |  40      5       |  56      7
   9      1       |  25      3       |  41      5       |  57      7
  10      1       |  26      3       |  42      5       |  58      7
  11      1       |  27      3       |  43      5       |  59      7
  12      1       |  28      3       |  44      5       |  60      7
  13      1       |  29      3       |  45      5       |  61      7
  14      1       |  30      3       |  46      5       |  62      7
  15      1       |  31      3       |  47      5       |  63      7

 L2 Traffic-Class + Color to EXP
 ----------------+-------- | ----------------+-------- | ----------------+----
----
      INPUT      | OUTPUT  |      INPUT      | OUTPUT  |      INPUT      |
OUTPUT
 ----------------+-------- | ----------------+-------- | ----------------+----
----
    TC  | Color  | EXP     |    TC  | Color  | EXP     |    TC  | Color  | EXP
 -------+--------+-------- | -------+--------+-------- | -------+--------+----
----
  0       green    0       |  0       yellow   0       |  0       red      0
  1       green    1       |  1       yellow   1       |  1       red      1
  2       green    2       |  2       yellow   2       |  2       red      2
  3       green    3       |  3       yellow   3       |  3       red      3
  4       green    4       |  4       yellow   4       |  4       red      4
  5       green    5       |  5       yellow   5       |  5       red      5
  6       green    6       |  6       yellow   6       |  6       red      6
  7       green    7       |  7       yellow   7       |  7       red      7

PE2#show qos default
profile name: default
profile type: cos-to-queue
configured mapping:
Detailed mapping:
 ---------------+----------------- | ---------------+-----------------
      INPUT     |      OUTPUT      |      INPUT     |      OUTPUT
 ---------------+----------------- | ---------------+-----------------
   COS  |  DEI  |   TC  |  Color   |   COS  |  DEI  |   TC  |  Color
 -------+-------+-------+--------- | -------+-------+-------+---------
  0       0       0       green    |  0       1       0       yellow
  1       0       1       green    |  1       1       1       yellow
  2       0       2       green    |  2       1       2       yellow
  3       0       3       green    |  3       1       3       yellow
```

```
  4       0       4       green    |  4       1       4       yellow
  5       0       5       green    |  5       1       5       yellow
  6       0       6       green    |  6       1       6       yellow
  7       0       7       green    |  7       1       7       yellow

profile name: default
profile type: queue-color-to-cos
configured mapping:
Detailed mapping:
 ----------------+-------- | ----------------+-------- | ----------------+----
----
      INPUT      | OUTPUT  |      INPUT      | OUTPUT  |      INPUT      |
OUTPUT
 ----------------+-------- | ----------------+-------- | ----------------+----
----
    TC  | Color  | COS     |    TC  | Color  | COS     |    TC  | Color  | COS
 -------+--------+-------- | -------+--------+-------- | -------+--------+----
----
  0       green    0       |  0       yellow   0       |  0       red      0
  1       green    1       |  1       yellow   1       |  1       red      1
  2       green    2       |  2       yellow   2       |  2       red      2
  3       green    3       |  3       yellow   3       |  3       red      3
  4       green    4       |  4       yellow   4       |  4       red      4
  5       green    5       |  5       yellow   5       |  5       red      5
  6       green    6       |  6       yellow   6       |  6       red      6
  7       green    7       |  7       yellow   7       |  7       red      7

profile name: default
profile type: dscp-to-queue
configured mapping:
Detailed mapping:
 -------+--------------------------- | -------+--------------------------- | -
------+--------------------------- | -------+---
------------------------
  INPUT |         OUTPUT             |  INPUT |         OUTPUT             |
INPUT |         OUTPUT             |  INPUT |
      OUTPUT
 -------+--------------------------- | -------+--------------------------- | -
------+--------------------------- | -------+---
------------------------
  DSCP  |   TC  | Color  | Out DSCP  |  DSCP  |   TC  | Color  | Out DSCP  |
DSCP  |   TC  | Color  | Out DSCP  |  DSCP  |
TC  | Color  | Out DSCP
 -------+-------+--------+---------- | -------+-------+--------+---------- | -
------+-------+--------+---------- | -------+---
----+--------+----------
   0      0       green     0        |  16      2       green    16        |
32      4       green    32        |  48      6
      green    48
   1      0       green     1        |  17      2       green    17        |
33      4       green    33        |  49      6
      green    49
   2      0       green     2        |  18      2       green    18        |
34      4       green    34        |  50      6
      green    50
   3      0       green     3        |  19      2       green    19        |
35      4       green    35        |  51      6
      green    51
```

```
    4      0        green     4         | 20       2       yellow   20         |
36     4       yellow   36         | 52      6
      green    52
    5      0        green     5         | 21       2       green    21         |
37     4       green    37         | 53      6
      green    53
    6      0        green     6         | 22       2       yellow   22         |
38     4       yellow   38         | 54      6
      green    54
    7      0        green     7         | 23       2       green    23         |
39     4       green    39         | 55      6
      green    55
    8      1        green     8         | 24       3       green    24         |
40     5       green    40         | 56      7
      green    56
    9      1        green     9         | 25       3       green    25         |
41     5       green    41         | 57      7
      green    57
   10      1        green    10         | 26       3       green    26         |
42     5       green    42         | 58      7
      green    58
   11      1        green    11         | 27       3       green    27         |
43     5       green    43         | 59      7
      green    59
   12      1        yellow   12         | 28       3       yellow   28         |
44     5       green    44         | 60      7
      green    60
   13      1        green    13         | 29       3       green    29         |
45     5       green    45         | 61      7
      green    61
   14      1        yellow   14         | 30       3       yellow   30         |
46     5       green    46         | 62      7
      green    62
   15      1        green    15         | 31       3       green    31         |
47     5       green    47         | 63      7
      green    63

profile name: default
profile type: queue-color-to-dscp
configured mapping:
Detailed mapping:
 ----------------+-------- | ----------------+-------- | ----------------+----
----
      INPUT      | OUTPUT  |      INPUT      | OUTPUT  |      INPUT      |
OUTPUT
 ----------------+-------- | ----------------+-------- | ----------------+----
----
    TC  | Color  | DSCP    |    TC  | Color  | DSCP    |    TC  | Color  |
DSCP
 -------+--------+-------- | -------+--------+-------- | -------+--------+----
----
  0       green     0      |  0       yellow    0      |  0       red       0
  1       green    10      |  1       yellow   12      |  1       red      14
  2       green    18      |  2       yellow   20      |  2       red      22
  3       green    26      |  3       yellow   28      |  3       red      30
  4       green    34      |  4       yellow   36      |  4       red      38
  5       green    40      |  5       yellow   40      |  5       red      40
  6       green    48      |  6       yellow   48      |  6       red      48
  7       green    56      |  7       yellow   56      |  7       red      56
```

```
profile name: default
profile type: dscp-to-dscp
configured mapping:
Detailed mapping:
 ---------------+---------- | ---------------+---------- | ---------------
+----------
      INPUT      |  OUTPUT   |      INPUT      |  OUTPUT   |      INPUT      |
OUTPUT
 ---------------+---------- | ---------------+---------- | ---------------
+----------
  DSCP |  Color   | Out DSCP  |  DSCP |  Color   | Out DSCP  |  DSCP |  Color   |
Out DSCP
 ------+---------+---------- | ------+---------+---------- | ------+---------
+----------
   0     green      0         |  0     yellow     0         |  0     red
0
   1     green      1         |  1     yellow     1         |  1     red
1
   2     green      2         |  2     yellow     2         |  2     red
2
   3     green      3         |  3     yellow     3         |  3     red
3
   4     green      4         |  4     yellow     4         |  4     red
4
   5     green      5         |  5     yellow     5         |  5     red
5
   6     green      6         |  6     yellow     6         |  6     red
6
   7     green      7         |  7     yellow     7         |  7     red
7
   8     green      8         |  8     yellow     8         |  8     red
8
   9     green      9         |  9     yellow     9         |  9     red
9
  10     green     10         | 10     yellow    12         | 10     red
14
  11     green     11         | 11     yellow    11         | 11     red
11
  12     green     12         | 12     yellow    12         | 12     red
14
  13     green     13         | 13     yellow    13         | 13     red
13
  14     green     14         | 14     yellow    14         | 14     red
14
  15     green     15         | 15     yellow    15         | 15     red
15
  16     green     16         | 16     yellow    16         | 16     red
16
  17     green     17         | 17     yellow    17         | 17     red
17
  18     green     18         | 18     yellow    20         | 18     red
22
  19     green     19         | 19     yellow    19         | 19     red
19
  20     green     20         | 20     yellow    20         | 20     red
22
  21     green     21         | 21     yellow    21         | 21     red
21
  22     green     22         | 22     yellow    22         | 22     red
22
  23     green     23         | 23     yellow    23         | 23     red
23
```

```
  24      green     24          |  24      yellow   24          |  24      red
24
  25      green     25          |  25      yellow   25          |  25      red
25
  26      green     26          |  26      yellow   28          |  26      red
30
  27      green     27          |  27      yellow   27          |  27      red
27
  28      green     28          |  28      yellow   28          |  28      red
30
  29      green     29          |  29      yellow   29          |  29      red
29
  30      green     30          |  30      yellow   30          |  30      red
30
  31      green     31          |  31      yellow   31          |  31      red
31
  32      green     32          |  32      yellow   32          |  32      red
32
  33      green     33          |  33      yellow   33          |  33      red
33
  34      green     34          |  34      yellow   36          |  34      red
38
  35      green     35          |  35      yellow   35          |  35      red
35
  36      green     36          |  36      yellow   36          |  36      red
38
  37      green     37          |  37      yellow   37          |  37      red
37
  38      green     38          |  38      yellow   38          |  38      red
38
  39      green     39          |  39      yellow   39          |  39      red
39
  40      green     40          |  40      yellow   40          |  40      red
40
  41      green     41          |  41      yellow   41          |  41      red
41
  42      green     42          |  42      yellow   42          |  42      red
42
  43      green     43          |  43      yellow   43          |  43      red
43
  44      green     44          |  44      yellow   44          |  44      red
44
  45      green     45          |  45      yellow   45          |  45      red
45
  46      green     46          |  46      yellow   46          |  46      red
46
  47      green     47          |  47      yellow   47          |  47      red
47
  48      green     48          |  48      yellow   48          |  48      red
48
  49      green     49          |  49      yellow   49          |  49      red
49
  50      green     50          |  50      yellow   50          |  50      red
50
  51      green     51          |  51      yellow   51          |  51      red
51
  52      green     52          |  52      yellow   52          |  52      red
52
  53      green     53          |  53      yellow   53          |  53      red
53
  54      green     54          |  54      yellow   54          |  54      red
54
```

```
  55     green     55         |  55     yellow    55         |  55     red
55
  56     green     56         |  56     yellow    56         |  56     red
56
  57     green     57         |  57     yellow    57         |  57     red
57
  58     green     58         |  58     yellow    58         |  58     red
58
  59     green     59         |  59     yellow    59         |  59     red
59
  60     green     60         |  60     yellow    60         |  60     red
60
  61     green     61         |  61     yellow    61         |  61     red
61
  62     green     62         |  62     yellow    62         |  62     red
62
  63     green     63         |  63     yellow    63         |  63     red
63

profile name: default
profile type: dscp-encap
configured mapping:
Detailed mapping:
 L3 DSCP to DSCP-ENCAP
 -------+--------  | -------+--------  | -------+--------  | -------+--------
  INPUT | OUTPUT   |  INPUT | OUTPUT   |  INPUT | OUTPUT   |  INPUT | OUTPUT
 -------|--------  | -------|--------  | -------|--------  | -------|--------
  DSCP  | DSCP     |  DSCP  | DSCP     |  DSCP  | DSCP     |  DSCP  | DSCP
 -------+--------  | -------+--------  | -------+--------  | -------+--------
   0        0      |  16       16      |  32       32      |  48       48
   1        1      |  17       17      |  33       33      |  49       49
   2        2      |  18       18      |  34       34      |  50       50
   3        3      |  19       19      |  35       35      |  51       51
   4        4      |  20       20      |  36       36      |  52       52
   5        5      |  21       21      |  37       37      |  53       53
   6        6      |  22       22      |  38       38      |  54       54
   7        7      |  23       23      |  39       39      |  55       55
   8        8      |  24       24      |  40       40      |  56       56
   9        9      |  25       25      |  41       41      |  57       57
  10       10      |  26       26      |  42       42      |  58       58
  11       11      |  27       27      |  43       43      |  59       59
  12       12      |  28       28      |  44       44      |  60       60
  13       13      |  29       29      |  45       45      |  61       61
  14       14      |  30       30      |  46       46      |  62       62
  15       15      |  31       31      |  47       47      |  63       63

 L2 Traffic-Class + Color to DSCP-ENCAP
 ---------------+-------- | ----------------+--------| --------------+--------
      INPUT     | OUTPUT  |       INPUT      | OUTPUT |      INPUT    | OUTPUT
 ---------------+-------- | ----------------+--------| --------------+--------
    TC   | Color | DSCP   |    TC   | Color   | DSCP   |   TC   | Color | DSCP
 -------+-------+-------- | -------+---------+--------| ------+-------+--------
  0      green      0     |  0      yellow     0      |  0      red        0
  1      green      8     |  1      yellow     8      |  1      red        8
  2      green     16     |  2      yellow    16      |  2      red       16
  3      green     24     |  3      yellow    24      |  3      red       24
  4      green     32     |  4      yellow    32      |  4      red       32
  5      green     40     |  5      yellow    40      |  5      red       40
```

```
  6      green     48     |  6      yellow    48     |  6      red       48
  7      green     56     |  7      yellow    56     |  7      red       56

profile name: default
profile type: exp-to-queue
configured mapping:
qos profile exp-to-queue default
 exp 5 queue 7
!
Detailed mapping:
 -------+-----------------
  INPUT |     OUTPUT
 -------+-----------------
  EXP   |   TC   | Color
 -------+--------+--------
  0       0        green
  1       1        green
  2       2        green
  3       3        green
  4       4        green
  5       7        green
  6       6        green
  7       7        green

profile name: default
profile type: exp-encap
configured mapping:
Detailed mapping:
 L3 DSCP to EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT  |  INPUT | OUTPUT
 -------|-------- | -------|-------- | -------|-------- | -------|--------
  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP     |  DSCP  | EXP
 -------+-------- | -------+-------- | -------+-------- | -------+--------
   0      0       |  16      2       |  32      4       |  48      6
   1      0       |  17      2       |  33      4       |  49      6
   2      0       |  18      2       |  34      4       |  50      6
   3      0       |  19      2       |  35      4       |  51      6
   4      0       |  20      2       |  36      4       |  52      6
   5      0       |  21      2       |  37      4       |  53      6
   6      0       |  22      2       |  38      4       |  54      6
   7      0       |  23      2       |  39      4       |  55      6
   8      1       |  24      3       |  40      5       |  56      7
   9      1       |  25      3       |  41      5       |  57      7
  10      1       |  26      3       |  42      5       |  58      7
  11      1       |  27      3       |  43      5       |  59      7
  12      1       |  28      3       |  44      5       |  60      7
  13      1       |  29      3       |  45      5       |  61      7
  14      1       |  30      3       |  46      5       |  62      7
  15      1       |  31      3       |  47      5       |  63      7

 L2 Traffic-Class + Color to EXP
 ----------------+-------- | ----------------+-------- | ----------------+----
----
      INPUT      | OUTPUT  |      INPUT      | OUTPUT  |      INPUT      |
OUTPUT
```

```
 ----------------+-------- | ----------------+-------- | ----------------+----
----
    TC  | Color  | EXP     |    TC  | Color  | EXP     |    TC  | Color  | EXP
 -------+--------+-------- | -------+--------+-------- | -------+--------+----
----
  0       green    0       |  0       yellow   0       |  0       red      0
  1       green    1       |  1       yellow   1       |  1       red      1
  2       green    2       |  2       yellow   2       |  2       red      2
  3       green    3       |  3       yellow   3       |  3       red      3
  4       green    4       |  4       yellow   4       |  4       red      4
  5       green    5       |  5       yellow   5       |  5       red      5
  6       green    6       |  6       yellow   6       |  6       red      6
  7       green    7       |  7       yellow   7       |  7       red      7
```

CHAPTER 7 Policing Configuration

This chapter contains a complete sample of configuration of Policing for Pipe and Uniform models.This example shows configurations using LDP.

Configuration

Configuring Remarking for MPLS EXP bits require following configurations:

- Enabling label-switching on the interface on NSM.
- Configuring LSP (Using LDP, Static or RSVP-TE, in this example we are using LDP for setting UP LSP).
- Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
- Enable QoS, Configuring Policing on interface Level.

Topology

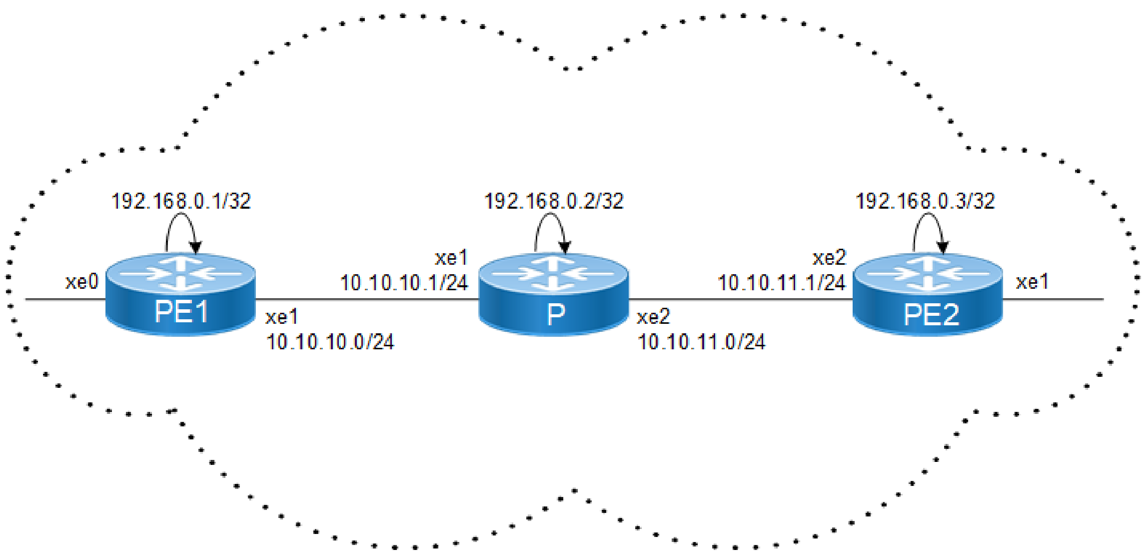

Figure 7-3: Basic Policing Topology

The following steps describes how to configure Policing.

PE1:NSM

`#configure terminal`	Enter configure mode
`(config)#interface xe1`	Specify the interface (xe1) to be configured.
`(config-if)#ip address 10.10.10.1/24`	Configure IP address for the interface
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.

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`(config-if)#ip address 192.168.0.1/32 secondary`	Set the IP address of the loopback interface to 192.168.0.1/32
`(config-if)#commit`	Commit the transaction.

PE1:OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

`(config-router)#network 10.10.10.0/24 area 0`
`(config-router)#network 192.168.0.1/32 area`
`0`
	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

`(config-router)#commit`	Commit the transaction.

PE1:LDP

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter Router mode for LDP.
`(config-router)#router-id 192.168.0.1`	Set the router ID to IP address 192.168.0.1.
`(config-router)#transport-address ipv4 192.168.0.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
`(config-router)#exit`	Exit router mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on xe1.
`(config-if)#commit`	Commit the transaction.

PE1

`#configure terminal`	Enter configure mode.
`(config)#qos enable`	Enable QoS.
`(config)#hardware-profile filter qos enable`	Enable QoS hardware.
`(config)#commit`	Commit candidate configuration to the running configuration.
`(config)#class-map cmap1`	Enter Class-map mode.
`(config-cmap-qos)#match dscp 2`	Configure match criteria as DSCP with Value 2.
`(config-cmap-qos)#exit`	Exit Class-map mode.
`(config)#commit`	Commit candidate configuration to the running configuration.
`(config)#policy-map pmap1`	Enter policy-map mode.
`(config-pmap-qos)#class cmap1`	Assign Class cmap1 to Policy-map pmap1.
`(config-pmap-c-qos)#police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes`	Police DSCP 2 packets @ Committed information rate 1 mbps.

(config-pmap-c-qos)#exit	Exit out of policy-class-map mode.
(config-pmap-qos)#exit	Exit out of Policy-map mode.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#interface xe1	Enter xe1 interface.
(config-if)#service-policy type qos input pmap1	Assign service-policy to interface on in-direction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to the running configuration.

P:NSM

#configure terminal	Enter configure mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.10.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.11.1/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.2/32 secondary	Set the IP address of the loopback interface to 192.168.0.2/32.
(config-if)#commit	Commit the transaction.

P:OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 10.10.11.0/24 area 0 (config-router)#network 192.168.0.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

P:LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.2	Set the router ID to IP address 192.168.0.2.

(config-router)#transport-address ipv4 192.168.0.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

PE2:NSM

#configure terminal	Enter configure mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#ip address 10.10.11.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 192.168.0.3/32 secondary	Set the IP address of the loopback interface to 192.168.0.3/32.
(config-if)#commit	Commit the transaction.

PE2:OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.11.0/24 area 0 (config-router)#network 192.168.0.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE2:LDP

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 192.168.0.3	Set the router ID to IP address 192.168.0.3.
(config-router)#explicit-null	To disable PHP.
(config-router)#transport-address ipv4 192.168.0.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address.

(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#qos enable	Enable QoS.
(config)#hardware-profile filter qos enable	Enable QoS hardware.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#class-map cmap1	Enter Class-map mode.
(config-cmap-qos)#match dscp 2	Configure match criteria as DSCP with Value 2.
(config-cmap-qos)#exit	Exit Class-map mode.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#policy-map pmap1	Enter policy-map mode.
(config-pmap-qos)#class cmap1	Assign Class cmap1 to Policy-map pmap1.
(config-pmap-c-qos)#police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes	Police DSCP 2 packets @ Committed information rate 1 mbps.
(config-pmap-c-qos)#exit	Exit out of policy-class-map mode.
(config-pmap-qos)#exit	Exit out of Policy-map mode.
(config)#commit	Commit candidate configuration to the running configuration.
(config)#interface xe1	Enter xe1 interface.
(config-if)#service-policy type qos input pmap1	Assign service-policy to interface on in-direction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to the running configuration.

Validation

PE1

```
PE1#show class-map

  Type qos class-maps
  ===================
      class-map type qos match-any class-default

      class-map type qos match-allcmap1
         match dscp 2


  Type queuing class-maps
  =======================
      class-map type queuing class-default-q
```

```
      class-map type queuing q0

      class-map type queuing q1

      class-map type queuing q2

      class-map type queuing q3

      class-map type queuing q4

      class-map type queuingq5

      class-map type queuing q6

      class-map type queuing q7


  Type Vlan-Queuing class-maps
  ============================


#show running-config qos
qos enable
!
class-map type qos match-all cmap1

match dscp 2
!
 policy-map type qos pmap1
 class type qos cmap1
 police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes
 exit
!
!
!
interface xe1
 service-policy type qos input pmap1
#

#show policy-map

Type qos policy-maps
====================

policy-map type qospmap1
 class Type qos cmap1
  police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes


Type queuing policy-maps
========================

policy-map type queuing default default-out-policy
 class type queuing default q0
  priority level 0
  exit
 class type queuing default q1
```

```
  priority level 1
  exit
 class type queuing default q2
  priority level 2
  exit
 class type queuing default q3
  priority level 3
  exit
 class type queuing default q4
  priority level 4
  exit
 class type queuing default q5
  priority level 5
  exit
 class type queuing default q6
  priority level 6
  exit
 class type queuing default q7
  priority level 7

policy-map type queuing default subif-default-out-policy
 class type queuing default q0
  priority level 0
 class type queuing default q1
  priority level 1
 class type queuing default q2
  priority level 2
 class type queuing default q3
  priority level 3


#show policy-map interface xe1
==============================

Interface xe1

Type QoS statistics status : disabled
========================================

Class-map (qos): cmap1 (match all)
 match dscp 2
 police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes


Type Queuing policy-map : default-out-policy
==============================================

Class-map (queuing): q0
 shape 10000000 kbps (inherited)
 priority level 0
 queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q1
 shape 10000000 kbps (inherited)
 priority level 1
 queue-limit 12517376 bytes/10 ms (default)
```

```
Class-map (queuing): q2
 shape 10000000 kbps (inherited)
 priority level 2
 queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q3
 shape 10000000 kbps (inherited)
 priority level 3
 queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q4
 shape 10000000 kbps (inherited)
 priority level 4
 queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q5
 shape 10000000 kbps (inherited)
 priority level 5
 queue-limit 12517376 bytes/10 ms (default)

Class-map (queuing): q6
 shape 10000000 kbps (inherited)
 priority level 6
 queue-limit 12517376 bytes/10 ms (default)
      Output
         Total        : 7 packets, 816 bytes
         Green        : 7 packets, 816 bytes
         Yellow       : 0 packets, 0 bytes

Class-map (queuing): q7

shape 10000000 kbps (inherited)
 priority level 7
 queue-limit 12517376 bytes/10 ms (default)
```

PE2

```
OcNOS#show class-map

  Type qos class-maps
  ===================
      class-map type qos match-any class-default

      class-map type qos match-all cmap1
         match dscp 2


  Type queuing class-maps
  =======================
      class-map type queuing class-default-q

      class-map type queuing q0

      class-map type queuing q1

      class-map type queuing q2
```

```
      class-map type queuing q3

      class-map type queuing q4

      class-map type queuing q5

      class-map type queuing q6

      class-map type queuing q7
```

```
OcNOS#show running-config qos
qos enable
!
class-map type qos match-all cmap1
 match dscp 2
!
policy-map type qos pmap1
 class type qos cmap1
  police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes
  exit
!
!
!
interface xe1
 service-policy type qos input pmap1
!
```

```
OcNOS#show policy-map

Type qos policy-maps
====================

policy-map type qos pmap1
 class type qos cmap1
  police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes


Type queuing policy-maps
========================

policy-map type queuing default default-out-policy
 class type queuing default q0
  priority level 0
 class type queuing default q1
  priority level 1
 class type queuing default q2
  priority level 2
 class type queuing default q3
  priority level 3
 class type queuing default q4
  priority level 4
 class type queuing default q5
```

```
  priority level 5
 class type queuing default q6
  priority level 6
 class type queuing default q7
  priority level 7

policy-map type queuing default subif-default-out-policy
 class type queuing default q0
  priority level 0
 class type queuing default q1
  priority level 1
 class type queuing default q2
  priority level 2
 class type queuing default q3
  priority level 3

OcNOS#show policy-map int xe15

Interface xe15

Type QoS statistics status : disabled

Type QoS Ingress policy-map : pmap1

Class-map (qos): cmap1 (match all)
 match dscp 2
 police cir 1 mbps eir 1 mbps bc 1 kbytes be 1 kbytes


Type Queuing policy-map : default-out-policy

Class-map (queuing): q0
 shape 10000000 kbps (inherited)
 priority level 0
 queue-limit  (default)
      Output
         Total        : 451 packets, 33887 bytes
         Green        : 451 packets, 33887 bytes
         Yellow       : 0 packets, 0 bytes

Class-map (queuing): q1
 shape 10000000 kbps (inherited)
 priority level 1
 queue-limit  (default)

Class-map (queuing): q2
 shape 10000000 kbps (inherited)
 priority level 2
 queue-limit  (default)

Class-map (queuing): q3
 shape 10000000 kbps (inherited)
 priority level 3
 queue-limit  (default)

Class-map (queuing): q4
 shape 10000000 kbps (inherited)
```

```
 priority level 4
 queue-limit  (default)

Class-map (queuing): q5
 shape 10000000 kbps (inherited)
 priority level 5
 queue-limit  (default)

Class-map (queuing): q6
 shape 10000000 kbps (inherited)
 priority level 6
 queue-limit  (default)
      Output
         Total        : 1119 packets, 100461 bytes
         Green        : 1119 packets, 100461 bytes
         Yellow       : 0 packets, 0 bytes

Class-map (queuing): q7
 shape 10000000 kbps (inherited)
 priority level 7
 queue-limit  (default)
      Output
         Total        : 56 packets, 4088 bytes
         Green        : 56 packets, 4088 bytes
         Yellow       : 0 packets, 0 bytes
```

CHAPTER 8 MPLS Statistics Configuration

This chapter provides the configuration required for configuring MPLS LSPs and verifying the statistics of packets captured at the supported interfaces, in terms of both packet count and bytes, when traffic is sent.

Configure LDP-LSP

Topology

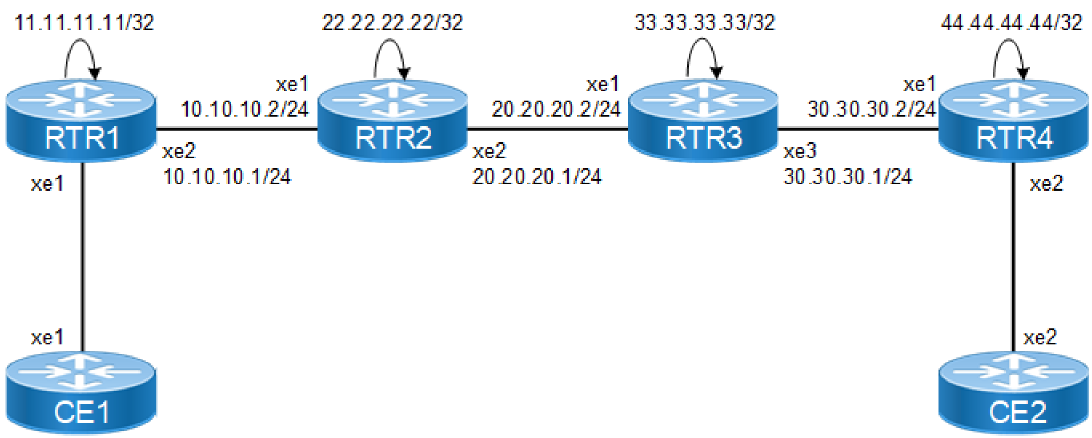

Figure 8-4: MPLS Statistics Topology

RTR1: Loopback Interface configuration

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the interface `(lo)` to be configured.
`(config-if)#ip address 11.11.11.11/32 secondary`	Configure IP address on loopback interface
`(config-if)#commit`	Commit the transaction.

RTR1: Global LDP configuration

`(config)#router ldp`	Enter `Router` mode for LDP.
`(config-router)#router-id 11.11.11.11`	Configure the router-id
`(config-router)#transport-address ipv4 11.11.11.11`	Configure the loopback address as transport-address
`(config-router)#targeted-peer ipv4 44.44.44.44`	Configure the loopback address of RTR4 as targeted peer.

(config-router-targeted-peer)#exit	Exit router-targeted-peer mode and enter config-router mode
(config-router-targeted-peer)#commit	Commit the transaction.

RTR1: Enabling LDP and label switching on interface

(config)#interface xe2	Enter interface mode for xe2.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 10.10.10.1/24	Configure IP address on the interface.
(config-if)#commit	Commit the transaction.

RTR1: Global OSPF configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 11.11.11.11/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.10.0/24 area 0	Advertise network address (xe2) in OSPF.
(config-router)#commit	Commit the transaction.

RTR2: Loopback Interface configuration

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the interface (lo) to be configured.
(config-if)#ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface
(config-if)#commit	Commit the transaction.

RTR2: Global LDP configuration

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 22.22.22.22	Configure the router-id
(config-router)#transport-address ipv4 22.22.22.22	Configure the loopback address as transport-address
(config-router)#commit	Commit the transaction.

RTR2: Enabling LDP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.

(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 10.10.10.2/24	Configure IP address on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 20.20.20.1/24	Configure IP address on the interface.
(config-if)#commit	Commit the transaction.

RTR2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode
(config-router)#network 22.22.22.22/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)#network 10.10.10.2/24 area 0.0.0.0	Advertise network address (xe1) in OSPF.
(config-router)#network 20.20.20.1/24 area 0.0.0.0	Advertise network address (xe2) in OSPF.
(config-router)#commit	Commit the transaction.

RTR3: Loopback Interface configuration

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the interface (lo) to be configured.
(config-if)#ip address 33.33.33.33/32 secondary	Configure IP address on loopback interface
(config-if)#commit	Commit the transaction.

RTR3: Global LDP configuration

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 33.33.33.33	Configure the router-id
(config-router)#transport-address ipv4 33.33.33.33	Configure the loopback address as transport-address
(config-router)#commit	Commit the transaction.

RTR3: Enabling LDP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.

`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#ip address 20.20.20.2/24`	Configure IP address on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Enter interface mode for xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#ip address 30.30.30.1/24`	Configure IP address on the interface.
`(config-if)#commit`	Commit the transaction.

RTR3: OSPF Configuration

`(config)#router ospf 100`	Enter the Router OSPF mode
`(config-router)#network 33.33.33.33/32 area 0.0.0.0`	Advertise loopback address in OSPF
`(config-router)#network 20.20.20.2/24 area 0.0.0.0`	Advertise network address (xe1) in OSPF.
`(config-router)#network 30.30.30.1/24 area 0.0.0.0`	Advertise network address (xe2) in OSPF.
`(config-router)#commit`	Commit the transaction.

RTR4: Loopback Interface configuration

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the interface `(lo)` to be configured.
`(config-if)#ip address 44.44.44.44/32 secondary`	Configure IP address on loopback interface
`(config-if)#commit`	Commit the transaction.

RTR4: Global LDP configuration

`(config)#router ldp`	Enter `Router` mode for LDP.
`(config-router)#router-id 44.44.44.44`	Configure the router-id
`(config-router)#transport-address ipv4 44.44.44.44`	Configure the loopback address as transport-address
`(config-router)#targeted-peer ipv4 11.11.11.11`	Configure the loopback address of RTR1 as targeted peer.
`(config-router-targeted-peer)#exit`	Exit router-targeted-peer mode and enter config-router mode
`(config-router)#commit`	Commit the transaction.

RTR4: Enabling LDP and label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#ip address 30.30.30.2/24	Configure IP address on the interface.
(config-if)#commit	Commit the transaction.

RTR4: Global OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode
(config-router)#network 44.44.44.44/32 area 0.0.0.0	Advertise loopback address in OSPF
(config-router)#network 30.30.30.2/24 area 0.0.0.0	Advertise network address (xe1) in OSPF.
(config-router)#commit	Commit the transaction.

MPLS LDP VPLS Configuration

RTR1: VPLS

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode
(config-vpls)# signaling ldp	Use LDP signaling for VPLS
(config-vpls-sig)#vpls-type ethernet	Configure the VPLS as Ethernet
(config-vpls-sig)#vpls-peer 44.44.44.44	Configure RTR4 as VPLS peer for RTR1.
(config-vpls-sig)#exit-signaling	Exit signaling mode
(config-vpls)# exit-vpls	Exit VPLS config mode and return to Configure mode
(config-vpls)#commit	Commit the transaction.

RTR1: Interface

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe1	Enter the Interface mode for xe1
(config-if)#switchport	Enable `switchport` on the interface
(config-if)#mpls-vpls vpls1 service-template st1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if)#commit	Commit the transaction.

RTR4: VPLS

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode
(config-vpls)#signaling ldp	Use LDP signaling for VPLS
(config-vpls-sig)#vpls-type ethernet	Configure the VPLS as Ethernet
(config-vpls-sig)#vpls-peer 11.11.11.11	Configure RTR1 as VPLS peer for RTR4.
(config-vpls-sig)#exit-signaling	Exit signaling mode
(config-vpls)#commit	Commit the transaction.

RTR4: Interface

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter the Interface mode for xe2
(config-if)#switchport	Enable `switchport` on the interface
(config-if)#mpls-vpls vpls1 service template st1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#commit	Commit the transaction.

Virtual Circuit Configuration

RTR1: Global VC Configuration

(config)#mpls l2-circuit t1 100 44.44.44.44	Enter the VC configuration command in router mode.
(config-pseudowire)#exit	Exit service template mode
(config)#bridge 1 protocol ieee vlan-bridge	Creating a VLAN-bridge in router mode.
(config)#commit	Commit the transaction.

RTR1: Interface Configuration

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template configuration
(config)#interface xe1	Enter interface mode for xe1.
(config-if)#switchport	Enable switchport on the interface.
(config-if)#mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if)#commit	Commit the transaction.

RTR4: Global VC Configuration

(config)#mpls l2-circuit t1 100 11.11.11.11	Enter the VC configuration command in router mode.
(config)#exit	Exit service template mode.
(config)#bridge 1 protocol ieee vlan-bridge	Creating a VLAN-bridge in router mode.
(config)#commit	Commit the transaction.

RTR4: Interface Configuration

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#switchport	Enable switchport on the interface.
(config-if)#mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config)#commit	Commit the transaction.

VPLS Configuration

RTR1: Global VPLS Configuration

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode.
(config-vpls)#signaling ldp	Use LDP signaling for VPLS.
(config-vpls-sig)#vpls-peer 44.44.44.44	Configure RTR4 as VPLS peer for RTR1.
(config-vpls-sig)#exit-signaling	Exit signaling mode.
(config-vpls)#commit	Commit the transaction.

RTR1: Interface Configuration

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe1	Enter interface mode for xe1.
(config-if)#switchport	Enable switchport on the interface.
(config-if)#mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls)#commit	Commit the transaction.

RTR4: Global VC Configuration

(config)#mpls vpls vpls1 1	Enter the VPLS configuration mode.
(config-vpls)#signaling ldp	Use LDP signaling for VPLS.
(config-vpls-sig)#vpls-peer 11.11.11.11	Configure RTR4 as VPLS peer for RTR1.

(config-vpls-sig)#exit-signaling	Exit signaling mode.
(config-vpls)#commit	Commit the transaction.

RTR4: Interface Configuration

(config)#service-template st1	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#switchport	Enable switchport on the interface.
(config-if)#mpls-vpls vpls1 service-template st1	Bind the interface to VPLS.
(config-if-vpls)#exit	Exit VPLS mode and return to interface mode.
(config-if)#commit	Commit the transaction.

Configure RSVP-LSP

RTR1: Global RSVP configuration

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#commit	Commit the transaction.

RTR1: Enabling RSVP and label switching on interface

(config)#interface xe2	Enter interface mode for xe2.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

RTR1: Trunk Configuration

(config)#rsvp-trunk t1	Configure RSVP trunk t1
(config-trunk)#to 44.44.44.44	Configure RTR4 as the end of trunk
(config-trunk)#commit	Commit the transaction.

RTR2: Global RSVP configuration

(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#php	Configure PHP on the end node.
(config-router)#commit	Commit the transaction.

RTR2: Enabling RSVP and label switching on interface

`(config)#interface xe1`	Enter interface mode for xe1.
`(config-if)#enable-rsvp`	Enable RSVP on the interface.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Enter interface mode for xe2.
`(config-if)#enable-rsvp`	Enable RSVP on the interface.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#commit`	Commit the transaction.

RTR3: Global RSVP configuration

`#configure terminal`	Enter configure mode.
`(config)#router rsvp`	Enter RSVP configuration mode for the router.
`(config-router)#php`	Configure PHP on the end node.
`(config-router)#commit`	Commit the transaction.

RTR3: Enabling RSVP and label switching on interface

`(config)#interface xe1`	Enter interface mode for xe1.
`(config-if)#enable-rsvp`	Enable RSVP on the interface.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe3`	Enter interface mode for xe3.
`(config-if)#enable-rsvp`	Enable RSVP on the interface.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#commit`	Commit the transaction.

RTR4: Global RSVP configuration

`#configure terminal`	Enter configure mode.
`(config)#router rsvp`	Enter RSVP configuration mode for the router.
`(config-router)#commit`	Commit the transaction.

RTR4: Enabling RSVP and label switching on interface

`(config)#interface xe1`	Enter interface mode for xe1.
`(config-if)#enable-rsvp`	Enable RSVP on the interface.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#commit`	Commit the transaction.

RTR4: Trunk Configuration

(config)#rsvp-trunk t2	Configure RSVP trunk t2.
(config-trunk)#to 11.11.11.11	Configure RTR1 as the end of trunk.
(config-trunk)#commit	Commit the transaction.

Configure Static-LSP

RTR1: Global Static configuration

(config)#mpls ftn-entry 44.44.44.44/32 100 10.10.10.2 xe1	Configure FTN entry for rtr4 loopback.
(config)#mpls ilm-entry 900 pop	Pop the incoming label
(config)#commit	Commit the transaction.

RTR1: Enabling label switching on interface

(config)#interface xe2	Enter interface mode for xe2.
(config-if)#label-switching	Enable Label switching on the interface.
(config)#commit	Commit the transaction.

RTR2: Global Static configuration

mpls ilm-entry 100 swap 200 xe2 20.20.20.2 44.44.44.44/32	Swap the incoming label
mpls ilm-entry 800 swap 900 xe1 10.10.10.1 11.11.11.11/32	Swap the incoming label

RTR2: Enabling label switching on interface

(config)#interface xe1	Enter interface mode for xe1.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode for xe2.
(config-if)#label-switching	Enable Label switching on the interface.
(config-if)#commit	Commit the transaction.

RTR3: Global Static configuration

(config)#mpls ilm-entry 200 swap 300 xe2 30.30.30.2 44.44.44.44/32	Swap the incoming label
(config)#mpls ilm-entry 700 swap 800 xe1 20.20.20.1 11.11.11.11/32	Swap the incoming label
(config)#commit	Commit the transaction.

RTR3: Enabling label switching on interface

`(config)#interface xe1`	Enter interface mode for xe1.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe3`	Enter interface mode for xe3.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#commit`	Commit the transaction.

RTR4: Global Static configuration

`(config)#mpls ftn-entry 11.11.11.11/32 700 30.30.30.1 xe1`	Configure FTN entry for RTR1 loopback.
`(config)mpls ilm-entry 300 pop`	Pop the incoming label.
`(config)#commit`	Commit the transaction.

RTR4: Enabling label switching on interface

`(config)#interface xe1`	Enter interface mode for xe1.
`(config-if)#label-switching`	Enable Label switching on the interface.
`(config-if)#commit`	Commit the transaction.

Validation

Here, 1000 packets are transmitted between the PE nodes and the output of counters at each node is mentioned below.

For Static-LSP

```
RTR1#show mpls counters static
[FTN statistics]
+-------------------+-----------+---------------------+---------------------+
|       FEC         | out-label |     Tx packets      |      Tx bytes       |
+-------------------+-----------+---------------------+---------------------+
 44.44.44.44/32     100         49939                 807798
[ILM statistics]
+-------------------+-----------+-----------+---------------------+-------------
-------+---------------------+---------------------+
|       FEC         | in-label  | out-label |     Rx packets      |       Rx
bytes      |     Tx packets      |       Tx bytes      |
+-------------------+-----------+-----------+---------------------+-------------
-------+---------------------+---------------------+
 0.0.0.0/0          900        n/a        40546                3486956
n/a                  n/a
RTR1#


RTR2#show mpls counters static
[FTN statistics]
```

```
+-----------------+----------+-------------------+-------------------+
|       FEC       | out-label |     Tx packets     |      Tx bytes      |
+-----------------+----------+-------------------+-------------------+

[ILM statistics]
+-----------------+----------+----------+-------------------+------------
--
-----+-------------------+-------------------+
|       FEC       | in-label  | out-label |     Rx packets     |      Rx
bytes
     |     Tx packets     |      Tx bytes      |
+-----------------+----------+----------+-------------------+------------
--
-----+-------------------+-------------------+
 44.44.44.44/32     100         200        9393                  807798
     9393                 807798
 11.11.11.11/32     800         900        40546                 3486956
     40546                3486956
RTR2#


RTR3#show mpls counters static
[FTN statistics]
+-----------------+----------+-------------------+-------------------+
|       FEC       | out-label |     Tx packets     |      Tx bytes      |
+-----------------+----------+-------------------+-------------------+

[ILM statistics]
+-----------------+----------+----------+-------------------+------------
-------+-------------------+-------------------+
|       FEC       | in-label  | out-label |     Rx packets     |      Rx
bytes      |     Tx packets     |      Tx bytes      |
+-----------------+----------+----------+-------------------+------------
-------+-------------------+-------------------+
 44.44.44.44/32    200        300       9393              807798
9393                807798
 11.11.11.11/32    700        800       40546             3486956
40546               3486956
RTR3#


RTR4#show mpls counters static
[FTN statistics]
+-----------------+----------+-------------------+-------------------+
|       FEC       | out-label |     Tx packets     |      Tx bytes      |
+-----------------+----------+-------------------+-------------------+
 11.11.11.11/32     700         49939               3486956

[ILM statistics]
+-----------------+----------+----------+-------------------+------------
--
-----+-------------------+-------------------+
|       FEC       | in-label  | out-label |     Rx packets     |      Rx
bytes
     |     Tx packets     |      Tx bytes      |
+-----------------+----------+----------+-------------------+------------
--
-----+-------------------+-------------------+
 0.0.0.0/0          300         n/a        9393                  807798
```

```
      n/a                  n/a
RTR4#
```

For RSVP-LSP

```
RTR1#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
 lsp-name : t1-Primary                                   [Egress]
 lsp-ingress : 44.44.44.44      lsp-id : 2201
 Rx pkts : 2509072              Rx bytes : 187780192
 Tx pkts : 0                    Tx bytes : 0

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
 lsp-name : t1-Primary                                   [Ingress]
 lsp-ingress : 11.11.11.11      lsp-id : 2201
 Rx pkts : 0                    Rx bytes : 0
 Tx pkts : 5578405              Tx bytes : 451417492


RTR2#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
 lsp-name : t1-Primary                                   [Transit]
 lsp-ingress : 44.44.44.44      lsp-id : 2201
 Rx pkts : 2565947              Rx bytes : 192671442
 Tx pkts : 2565960              Tx bytes : 192672560

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
 lsp-name : t1-Primary                                   [Transit]
 lsp-ingress : 11.11.11.11      lsp-id : 2201
 Rx pkts : 5631460              Rx bytes : 456305560
 Tx pkts : 5631472              Tx bytes : 456306592


RTR3#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
 lsp-name : t1-Primary                                   [Transit]
 lsp-ingress : 44.44.44.44      lsp-id : 2201
 Rx pkts : 2565947              Rx bytes : 282671442
 Tx pkts : 2565960              Tx bytes : 282672560

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
 lsp-name : t1-Primary                                   [Transit]
 lsp-ingress : 11.11.11.11      lsp-id : 2201
 Rx pkts : 8631460              Rx bytes : 457245560
 Tx pkts : 8631472              Tx bytes : 45724592


RTR4#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11
 lsp-name : t1-Primary                                   [Ingress]
 lsp-ingress : 44.44.44.44      lsp-id : 2201
 Rx pkts : 0                    Rx bytes : 0
 Tx pkts : 10231330             Tx bytes : 374371318

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44
 lsp-name : t1-Primary                                   [Egress]
```

```
 lsp-ingress : 11.11.11.11      lsp-id : 2201
 Rx pkts : 5651207              Rx bytes : 458003802
 Tx pkts : 0                    Tx bytes : 0

R3#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11 lsp-name :
t1-Primary[Transit]
lsp-ingress : 44.44.44.44lsp-id : 2201
Rx pkts : 2565947Rx bytes : 282671442
Tx pkts : 2565960Tx bytes : 282672560

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44 lsp-name :
t1-Primary[Transit]
lsp-ingress : 11.11.11.11lsp-id : 2201
Rx pkts : 8631460Rx bytes : 457245560
Tx pkts : 8631472Tx bytes : 45724592

R4#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 44.44.44.44 Egress 11.11.11.11 lsp-name :
t1-Primary[Ingress]
lsp-ingress : 44.44.44.44lsp-id : 2201 Rx pkts : 0Rx bytes : 0
Tx pkts : 10231330Tx bytes : 374371318

Tunnel-id 5001 Extended Tunnel-ID 11.11.11.11 Egress 44.44.44.44 lsp-name :
t1-Primary[Egress]
lsp-ingress : 11.11.11.11lsp-id : 2201
Rx pkts : 5651207Rx bytes : 458003802
Tx pkts : 0Tx bytes : 0
```

For LDP-LSP

```
RTR1#show mpls counters ldp
[FTN statistics]
+------------------+-----------+--------------------+--------------------+
|       FEC          | out-label |   Tx packets    |      Tx bytes      |
+------------------+-------------+------------------+--------------------+
 44.44.44.44/32     52483         1000                 1004000
[ILM statistics]
+-----+---------+-----------+------------+---------+-----------+---------+
| FEC |in-label | out-label | Rx packets | Rx bytes| Tx packets| Tx bytes|
+-----+---------+-----------+------------+---------+-----------+---------+

RTR2#show mpls counters ldp
[FTN statistics]
+------------------+-----------+--------------------+--------------------+
|       FEC        | out-label |     Tx packets     |      Tx bytes      |
+------------------+-----------+--------------------+--------------------+
[ILM statistics]
+-----+----------+-----------+------------+----------+------------+----------+
| FEC | in-label | out-label | Rx packets | Rx bytes | Tx packets | Tx bytes |
+-----+----------+-----------+------------+----------+------------+----------+
44.44.44.44/32     52483   52483  1000        1004000   1000         1004000

/RTR2#show mpls counters ldp [FTN statistics]
+------------------+-----------+--------------------+--------------------+
|       FEC        | out-label |     Tx packets     |      Tx bytes      |
```

```
+-----------------+----------+------------------+------------------+
[ILM statistics]
+-----+----------+-----------+------------+----------+------------+----------+
| FEC | in-label | out-label | Rx packets | Rx bytes | Tx packets | Tx bytes |
+-----+----------+-----------+------------+----------+------------+----------+
44.44.44.44/325248352483 1000100400010001004000
```

For LDP-VC

```
RTR1#show mpls l2-circuit t1 statistics
MPLS Layer-2 Virtual Circuit: t1, id 100
 Access port statistics:
   RX:  Input packets  : 0
        Input bytes    : 0
   TX:  Output packets : 4642811
        Output bytes   : 297139904

 Network port statistics:
   RX:  Input packets  : 4642804
        Input bytes    : 399281144
   TX:  Output packets : 0
        Output bytes   : 0


RTR4#show mpls l2-circuit t1 statistics
MPLS Layer-2 Virtual Circuit: t1, id 100
 Access port statistics:
   RX:  Input packets  : 4633957
        Input bytes    : 296573248
   TX:  Output packets : 0
        Output bytes   : 0

 Network port statistics:
   RX:  Input packets  : 0
        Input bytes    : 0
   TX:  Output packets : 4633960
        Output bytes   : 398520560
```

For LDP-VPLS

```
RTR1#show mpls vpls vpls1 statistics
Virtual Private LAN Service Instance: vpls1, ID: 1

 Access port statistics:
 Interface: xe1
   RX:  Input packets  : 1922483
        Input bytes    : 123038912
   TX:  Output packets : 3894242
        Output bytes   : 126192000

 Network port statistics:
 Mesh Peer: 44.44.44.44 (Up)
   RX:  Input packets  : 1971746
        Input bytes    : 169570156
   TX:  Output packets : 3894244
```

```
        Output bytes   : 165334398


RTR4#show mpls vpls vpls1 statistics
Virtual Private LAN Service Instance: vpls1, ID: 1

 Access port statistics:
 Interface: xe2
   RX:  Input packets  : 1967571
        Input bytes    : 125924544
   TX:  Output packets : 3885889
        Output bytes   : 122772032

 Network port statistics:
 Mesh Peer: 11.11.11.11 (Up)
   RX:  Input packets  : 1918310
        Input bytes    : 164974660
   TX:  Output packets : 3885892
        Output bytes   : 169211622
```

CHAPTER 9 Anycast Gateway Routing for Multiple Subnets in EVPN-IRB

Overview

In the Ethernet VPN Integrated Routing and Bridging (EVPN-IRB) scenario, any two Layer 2 Virtual Network Identifiers (L2 VNID) nodes communicate using the Routing IP Virtual Routing and Forwarding (VRF). This communication is enriched with Anycast Gateway Routing to accommodate communication among multiple subnets under the IRB interface (per VNID).

In the current implementation, the router's primary IPv4 or IPv6 address is either Router Media Access Control (MAC) or Anycast MAC, and the secondary IPv4 or IPv6 address is always the Router MAC address. Hence, Anycast MAC support was only for the primary IP with a single subnet.

Additionally, the BGP router cannot establish a connection with the primary IP as it is in Anycast mode, and the TCP connection is possible only with any of the routers, as both the routes have the IP as Anycast.

To overcome this drawback, the feature is enhanced to configure both Router MAC or Anycast MAC for both primary and secondary subnets.

By default, each subnet uses the Router MAC address received from the ARP/ND cache. The `anycast` argument in `evpn irb-if forwarding anycast gateway` CLI is used to configure the Anycast MAC for primary or secondary subnets. The argument helps to update the ARP/ND cache with Anycast MAC. This enables the user to use Anycast MAC for multiple subnets under L2 VNID. For example, users can have Subnets A, B, C with Anycast MAC and Subnet D with Router MAC.

Feature Characteristics

This feature enhancement provides the following support:

- Enables configuration of either a Router MAC or an Anycast MAC address for primary or secondary subnets.
- Use of Anycast or Routing IP Gateway for multiple subnets under the Layer-2 VNID's.
- Flexibility to have Anycast Gateway for multiple subnets (for example, Subnet A, B, and C) while allowing the other subnet (for example, Subnet D) to be reserved for BGP.
- The InterfaceFull model that provides the flexibility to respond to the ARP/ND requests from the ARP/ND table.
- The InterfaceLess model that use the kernel interface with a unique MAC per interface, either Router MAC or Anycast MAC for all the subnets.

LIMITATIONS:

In InterfaceLess model, the kernel IRB interface has a single MAC that is either Router MAC or Anycast MAC, however, the response message always has Anycast MAC irrespective of whether the interface's IP address is Anycast or Router MAC.

Benefits

Allows users to have primary and secondary subnets with either Router MAC or Anycast MAC. This flexibility provides support for Anycast Gateway for multiple subnets under Layer 2 VNIDs.

Configuration

Following configuration illustrates how to use the `anycast` argument in `evpn irb-if forwarding anycast gateway` CLI to configure the Anycast MAC for both primary or secondary subnets.

Topology

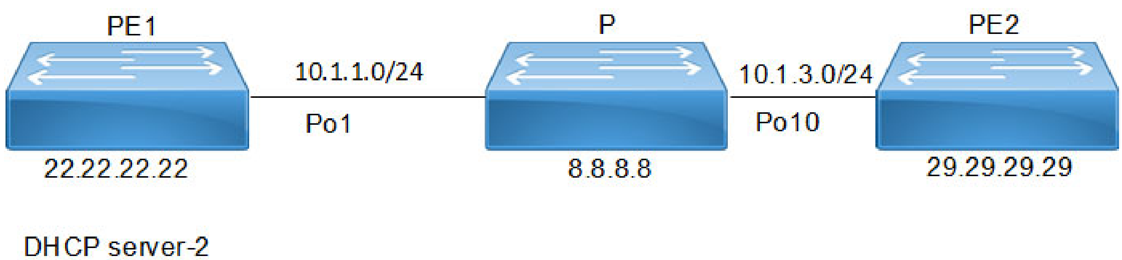

Figure 9-1: Anycast Gateway support for subnets

PE1 Configuration

PE1: Loopback Interface

`PE1(config)#interface lo`	Enter the loopback interface mode.
`PE1(config-if)#ip address 22.22.22.22/32 secondary`	Configure the IP address on loopback interface.
`PE1(config-if)#ip router isis ISIS-100`	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
`PE1(config-if)#enable-ldp ipv4`	Enable the LDP IPv4.
`PE1(config-if)#Commit`	Commit the configurations
`PE1(config-if)#exit`	Exit the configuration mode.

PE1: Global LDP

`PE1(config)#router ldp`	Enter the Router LDP mode.
`PE1(config-router)#router-id 22.22.22.22`	Enter the LDP router-id.
`PE1(config-router)#targeted-peer ipv4 29.29.29.29`	Configure the LDP target peer address.
`PE1(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted peer mode.

`PE1(config-router)#transport-address ipv4 22.22.22.22`	Configure the LDP transport address.
`PE1(config-router)#Commit`	Commit the configurations
`PE1(config-router)#exit`	Exit the configuration mode.

PE1: Interface Configuration on Network Side

`PE1(config)#interface po1`	Enter the Interface mode for the port channel interface
`PE1(config-if)#ip address 10.1.1.22/24`	Configure the IP address on port channel interface
`PE1(config-if)#label-switching`	Enable the label switching
`PE1(config-if)#ip router isis ISIS-100`	Enable the IS-IS routing on an interface for area 49 (ISIS-100)
`PE1(config-if)#enable-ldp ipv4`	Enable the LDP IPv4
`PE1(config-if)#interface xe22`	Enter interface mode
`PE1(config-if)#channel-group 1 mode active`	Moving interface to Dynamic LAG 1
`PE1(config-if)#Commit`	Commit the configurations
`PE1(config-if)#exit`	Exit the configuration mode.

PE1: IGP-ISIS Configuration

`PE1(config)#router isis ISIS-100`	Create an ISIS routing instance for area 49 (ISIS-100).
`PE1(config-router)#is-type level-1`	Configure instance as level-1 routing.
`PE1(config-router)#metric-style wide`	Configure the new style of metric type as wide.
`PE1(config-router)#mpls traffic-eng router-id 22.22.22.22`	Configure MPLS-TE unique router-id TLV.
`PE1(config-router)#mpls traffic-eng level-1`	Enable the MPLS-TE in is-type Level-1.
`PE1(config-router)#capability cspf`	Enable the Constrained Shortest Path First (CSPF).
`PE1(config-router)#dynamic-hostname`	Configure the host name to be advertised for an ISIS instance.
`PE1(config-router)#net 49.0001.0000.0000.0001.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID.
`PE1(config-router)#Commit`	Commit the configurations
`PE1(config-router)#exit`	Exit the configuration mode.

PE1: BGP Configuration

`PE1(config)#router bgp 65535`	Enter into Router BGP mode.
`PE1(config-router)#bgp router-id 22.22.22.22`	Configure router-id as 22.22.22.22 (loopback ip address).
`PE1(config-router)#neighbor 29.29.29.29 remote-as 65535`	Configuring PE2 as iBGP neighbor using it's loopback IP.
`PE1(config-router)#neighbor 29.29.29.29 update- source lo`	Source of routing updates as loopback.
`PE1(config-router)#neighbor 29.29.29.29 advertisement-interval 0`	Configure advertisement-interval as 0 for fast convergence for PE2

PE1(config-router)#address-family l2vpn evpn	Enter into l2vpn EVPN address family mode.
PE1(config-router-af)#neighbor 29.29.29.29 active	Enabling EVPN Address family for neighbor.
PE1(config-router-af)#exit-address-family	Exiting of Address family mode.
PE1(config-router)#address-family ipv4 vrf ip_vrf205_mgmt	Entering into VRF address family mode.
PE1(config-router-af)#redistribute connected	Redistribute connected routes to the network.
PE1(config-router-af)#exit-address-family	Exiting of Address family mode.
PE1(config-router)#Commit	Commit the configurations
PE1(config-router)#exit	Exit the configuration mode.

PE1: Global EVPN MPLS Command

PE1(config)#evpn mpls enable	Enable the EVPN MPLS globally.
PE1(config)#evpn mpls irb	Enable the EVPN MPLS IRB globally.
PE1(config)#evpn mpls multihoming enable	Enable the Multi homing, save configures and reboot the board for multi homing to be effective.
PE1(config)#qos enable	Enable the QOS.
PE1(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4455	Configure anycast gateway MAC globally.
PE1(config)#evpn mpls vtep-ip-global 22.22.22.22	Configure VTEP global IP.
PE1(config)#Commit	Commit the configurations
PE1(config)#exit	Exit the configuration mode.

PE1: MAC VRF Configuration

PE1(config)#mac vrf vrf205_mgmt	Enter Mac VRF mode.
PE1(config-vrf)#rd 22.22.22.22:205	Configuring Route-Distinguisher value.
PE1(config-vrf)#route-target both evpn-auto-rt	Configuring import and export value as evpn-auto-rt. Route targets will be derived automatically.
PE1(config-vrf)#Commit	Commit the configurations
PE1(config-vrf)#exit	Exit the configuration mode.

PE1: IP VRF Configuration

`PE1(config)#ip vrf ip_vrf205_mgmt`	Enter IP VRF mode
`PE1(config-vrf)#rd 22.22.22.22:305`	Configuring Route-Distinguisher value
`PE1(config-vrf)#route-target both 305:305`	Configuring route target values i.e import and export values
`PE1(config-vrf)#l3vni 305`	Configure L3 VNID for routing
`PE1(config-vrf)#Commit`	Commit the configurations
`PE1(config-vrf)#exit`	Exit the configuration mode.

PE1: IRB Interface Configuration with multiple IPs

`PE1(config)#interface irb127`	Create IRB interface irb127
`PE1(config-irb-if)#ip vrf forwarding ip_vrf205_mgmt`	Bind the VRF instance to the interface
`PE1(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac`	Enable an IRB interface to use the global anycast IRB mac-address
`PE1(config-irb-if)#ip address 98.98.101.1/24 anycast`	Configure the IPv4 primary address and use anycast mac address
`PE1(config-irb-if)#ip address 103.103.102.1/24 secondary`	Configure secondary IPv4 secondary address
`PE1(config-irb-if)#ip address 104.104.103.1/24 secondary anycast`	Configure secondary IPv4 secondary address and use as anycast mac address
`PE1(config-irb-if)#Commit`	Commit the configurations
`PE1(config-irb-if)#exit`	Exit the configuration mode.

PE1: EVPN MPLS Id Configuration

`PE1(config)#evpn mpls id 127`	Configure secondary IPv4 secondary address
`PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf205_mgmt`	Map the MAC VRF red
`PE1(config-evpn-mpls)#evpn irb irb127`	Map the IRB interface
`PE1(config-evpn-mpls)#commit`	Commit the configurations
`PE1(config-evpn-mpls)#exit`	Exit the configuration mode.

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PE1: Interface Configuration on Access Side

`PE1(config)#interface xe72.127 switchport`	Creating L2 sub interface of physical interface xe72
`PE1(config-if)#encapsulation dot1q 127`	Setting Encapsulation to dot1q with VLAN ID 127 Supported Encapsulation: dot1ad, dot1q, untagged, default
`PE1(config-if)#rewrite pop`	Configure rewrite with action pop
`PE1(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration
`PE1(config-acc-if-evpn)#map vpn-id 127`	Map VPN-ID 127
`PE1(config-acc-if-evpn)#Commit`	Commit the configurations
`PE1(config-acc-if-evpn)#exit`	Exit the configuration mode.

P Configuration

P: Loopback Interface

`P(config)#interface lo`	Enter the Interface mode for the loopback interface.
`P(config-if)#ip address 8.8.8.8/32 secondary`	Configure the IP address on loopback interface.
`P(config-if)#ip router isis ISIS-100`	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
`P(config-if)#enable-ldp ipv4`	Enable the LDP IPv4.
`P(config-if)#Commit`	Commit the configurations
`P(config-if)#exit`	Exit the configuration mode.

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P: Global LDP

P(config)#router ldp	Enter the Router LDP mode.
P(config-router)#router-id 8.8.8.8	Enter the LDP router-id.
P(config-router)#transport-address ipv4 8.8.8.8	Configure the LDP transport address.
P(config-router)#Commit	Commit the configurations
P(config-router)#exit	Exit the configuration mode.

P: Interface Configuration on Network Side

P(config)#interface po1	Enter the Interface mode for the port channel interface.
P(config-if)#ip address 10.1.1.8/24	Configure the IP address on port channel interface.
P(config-if)#label-switching	Enable the label switching.
P(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
P(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
P(config-if)#Commit	Commit the configurations
P(config-if)#exit	Exit the configuration mode.
P(config)#interface xe22	Enter interface mode.
P(config-if)#channel-group 1 mode active	Moving interface to Dynamic LAG 1.
P(config-if)#Commit	Commit the configurations
P(config-if)#exit	Exit the configuration mode.
P(config)#interface po10	Enter the Interface mode for the port channel interface.
P(config-if)#ip address 10.1.3.8/24	Configure the IP address on port channel interface.
P(config-if)#label-switching	Enable the label switching.
P(config-if)#ip router isis ISIS-100	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
P(config-if)#enable-ldp ipv4	Enable the LDP IPv4.
P(config-if)#interface xe10	Enter interface mode.
P(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10.
P(config-if)#Commit	Commit the configurations
P(config-if)#exit	Exit the configuration mode.

P: IGP-ISIS Configuration

P(config)#router isis ISIS-100	Create an IS-IS routing instance for area 49 (ISIS-100).
P(config-router)#is-type level-1	Configure the instance as level-1 routing.
P(config-router)#metric-style wide	Configure the new style of metric type as wide.
P(config-router)#mpls traffic-eng router-id 8.8.8.8	Configure MPLS-TE unique router-id TLV.
P(config-router)#mpls traffic-eng level-1	Enable the MPLS-TE in is-type Level-1.
P(config-router)#capability cspf	Enable the CSPF (Constrained Shortest Path First).
P(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.

`P(config-router)#net 49.0001.0000.0000.0002.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID.
`P(config-router)#Commit`	Commit the configurations
`P(config-router)#exit`	Exit the configuration mode.

PE2 Configuration

PE2: Loopback Interface

`PE2(config)#interface lo`	Enter the Interface mode for the loopback interface.
`PE2(config-if)#ip address 29.29.29.29/32 secondary`	Configure the IP address on loopback interface.
`PE2(config-if)#ip router isis ISIS-100`	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
`PE2(config-if)#enable-ldp ipv4`	Enable the LDP IPv4.
`PE2(config-if)#Commit`	Commit the configurations
`PE2(config-if)#exit`	Exit the configuration mode.

PE2: Global LDP

`PE2(config)#router ldp`	Enter the Router LDP mode.
`PE2(config-router)#router-id 29.29.29.29`	Enter the LDP router-id.
`PE2(config-router)#targeted-peer ipv4 22.22.22.22`	Configure the LDP target peer address.
`PE2(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted peer mode.
`PE2(config-router)#transport-address ipv4 29.29.29.29`	Configure the LDP transport address.
`PE2(config-router)#Commit`	Commit the configurations
`PE2(config-router)#exit`	Exit the configuration mode.

PE2: Global LDP

`PE2(config)#router ldp`	Enter the Router LDP mode.
`PE2(config-router)#router-id 29.29.29.29`	Enter the LDP router-id.
`PE2(config-router)#targeted-peer ipv4 22.22.22.22`	Configure the LDP target peer address.
`PE2(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted peer mode.
`PE2(config-router)#transport-address ipv4 29.29.29.29`	Configure the LDP transport address.
`PE2(config-router)#Commit`	Commit the configurations
`PE2(config-router)#exit`	Exit the configuration mode.

PE2: Interface Configuration on Network Side

`PE2(config)#interface po10`	Enter the Interface mode for the port channel interface.
`PE2(config-if)#ip address 10.1.3.29/24`	Configure the IP address on port channel interface.
`PE2(config-if)#label-switching`	Enable the label switching.
`PE2(config-if)#ip router isis ISIS-100`	Enable the IS-IS routing on an interface for area 49 (ISIS-100).
`PE2(config-if)#enable-ldp ipv4`	Enable the LDP IPv4.
`PE2(config-if)#interface ge1`	Enter interface mode.

`PE2(config-if)#channel-group 10 mode active`	Moving interface to Dynamic LAG 10.
`PE2(config-if)#Commit`	Commit the configurations
`PE2(config-if)#exit`	Exit the configuration mode.

PE2: IGP-ISIS Configuration

PE2(config)#router isis ISIS-100	Create an IS-IS routing instance for area 49 (ISIS-100).
PE2(config-router)#is-type level-1	Configure instance as level-1 routing.
PE2(config-router)#metric-style wide	Configure the new style of metric type as wide.
PE2(config-router)#mpls traffic-eng router-id 29.29.29.29	Configure MPLS-TE unique router-id TLV.
PE2(config-router)#mpls traffic-eng level-1	Enable the MPLS-TE in is-type Level-1.
PE2(config-router)#capability cspf	Enable the CSPF (Constrained Shortest Path First).
PE2(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
PE2(config-router)#net 49.0001.0000.0000.0029.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
PE2(config-router)#Commit	Commit the configurations
PE2(config-router)#exit	Exit the configuration mode.

PE2: BGP Configuration

PE2(config)#router bgp 65535	Enter into Router BGP mode.
PE2(config-router)#bgp router-id 29.29.29.29	Configure router-id as 29.29.29.29 (loopback ip address).
PE2(config-router)#neighbor 22.22.22.22 remote-as 65535	Configuring PE2 as iBGP neighbor using it's loopback IP.
PE2(config-router)#neighbor 22.22.22.22 update- source lo	Source of routing updates as loopback.
PE2(config-router)#neighbor 22.22.22.22 advertisement-interval 0	Configure advertisement-interval as 0 for fast convergence for PE2.
PE2(config-router)#address-family l2vpn evpn	Enter into l2vpn EVPN address family mode.
PE2(config-router-af)#neighbor 22.22.22.22 active	Enabling EVPN Address family for neighbor.
PE2(config-router-af)#exit-address-family	Exiting of Address family mode.
PE2(config-router)#address-family ipv4 vrf ip_vrf205_mgmt	Entering into VRF address family mode.
PE2(config-router-af)#redistribute connected	Redistribute connected routes to the network.
PE2(config-router-af)#exit-address-family	Exiting of Address family mode.
PE2(config-router-af)#commit	Commit the configurations
PE2(config-router-af)#exit	Exit the configuration mode.

PE2: Global EVPN MPLS Command

PE2(config)#evpn mpls enable	Enable the EVPN MPLS globally.
PE2(config)#evpn mpls irb	Enable the EVPN MPLS IRB globally.
PE2(config)#evpn mpls multihoming enable	Enable the Multihoming, save configs and reboot the board for multihoming to be effective.
PE2(config)#qos enable	Enable the QOS.

`PE2(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4567`	Configure anycast gateway MAC globally.
`PE2(config)#evpn mpls vtep-ip-global 29.29.29.29`	Configure VTEP global IP.
`PE2(config)#Commit`	Commit the configurations
`PE2(config)#exit`	Exit the configuration mode.

PE2: MAC VRF Configuration

PE2(config)#mac vrf vrf205_mgmt	Enter Mac VRF mode.
PE2(config-vrf)#rd 29.29.29.29:205	Configuring Route-Distinguisher value.
PE2(config-vrf)#route-target both evpn-auto-rt	Configuring import and export value as evpn-auto-rt. Route target will be derived automatically.
PE2(config-vrf)#Commit	Commit the configurations
PE2(config-vrf#exit	Exit the configuration mode.

PE2: IP VRF Configuration

PE2(config)#ip vrf ip_vrf205_mgmt	Enter IP VRF mode.
PE2(config-vrf)#rd 29.29.29.29:305	Configuring Route-Distinguisher value.
PE2(config-vrf)#route-target both 305:305	Configuring route target values i.e import and export values.
PE2(config-vrf)#l3vni 305	Configure L3 VNID for routing.
PE2(config-vrf)#Commit	Commit the configurations
PE2(config-vrf)#exit	Exit the configuration mode.

PE2: IRB Interface Configuration with multiple IPs

PE2(config)#interface irb127	Create IRB interface irb127.
PE2(config-irb-if)#ip vrf forwarding ip_vrf205_mgmt	Bind the VRF instance to the interface.
PE2(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac	Enable an IRB interface to use the global anycast IRB mac-address.
PE2(config-irb-if)#ip address 99.99.101.1/24 anycast	Configure the IPv4 primary address and use anycast mac address.
PE2(config-irb-if)#ip address 103.103.103.1/24 secondary	Configure secondary IPv4 secondary address.
PE2(config-irb-if)#ip address 104.104.104.1/24 secondary anycast	Configure secondary IPv4 secondary address and use as anycast mac address.
PE2(config-rib-if)#Commit	Commit the configurations
PE2(config-rib-if)#exit	Exit the configuration mode.

PE2: EVPN MPLS Id Configuration

PE2(config)#evpn mpls id 127	Configure secondary IPv4 secondary address.
PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf205_mgmt	Map the MAC VRF red.
PE2(config-evpn-mpls)#evpn irb irb127	Map the IRB interface.
PE2(config-evpn-mpls)#commit	Commit the configurations
PE2(config-evpn-mpls)#exit	Exit the configuration mode.

PE2: Interface Configuration on Access Side

`PE2(config)#interface xe12.127 switchport`	Creating L2 sub interface on physical interface xe12.
`PE2(config-if)#encapsulation dot1q 127`	Setting Encapsulation to dot1q with VLAN ID 127 Supported Encapsulation: dot1ad, dot1q, untagged, default.
`PE2(config-if)#rewrite pop`	Configure rewrite with action pop.
`PE2(config-if)#access-if-evpn`	Entering Access mode for EVPN MPLS ID configuration.
`PE2(config-acc-if-evpn)#map vpn-id 127`	Map VPN-ID 127.
`PE2(config-acc-if-evpn)#Commit`	Commit the configurations
`PE2(config-acc-if-evpn)#exit`	Exit the configuration mode.

Validation

Verify installed EVPN MPLS tunnels information.

PE1:

```
#show evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                           VLAN      DF-Status Src-Addr        Dst-Addr
___________________________________________________________________________________________________________________________
127      ----         L2       NW   ----      ----                          ----      ----      22.22.22.22     29.29.29.29
127      ----         --       AC   xe72.127  --- Single Homed Port ---     ----      ----      ----            ----
```

PE2:

```
#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source            Destination       Status         Up/Down        Update         evpn-id
=================================================================================
22.22.22.22       29.29.29.29       Installed      11:40:31       11:40:31       127
```

Verify the MAC addresses that are cached in the EVPN MAC and ARP table.

Verify the Anycast Gateway MAC addresses that are updated when configuring subnets with Anycast MAC:

PE1 verification:

```
#show evpn mpls mac-table
=============================================================================================================================
                                                 EVPN MPLS MAC Entries
=============================================================================================================================
VNID       Interface VlanId    In-VlanId Mac-Addr       VTEP-Ip/ESI                     Type           Status     MAC move
AccessPortDesc
_____________________________________________________________________________________________________________________________
127       irb127    ----      ----      0011.2233.4455 22.22.22.22                  Static Local    -------    0         -------
127       irb127    ----      ----      e49d.73b3.c101 22.22.22.22                  Static Local    -------    0         -------
127       ----      ----      ----      0011.2233.4567 29.29.29.29                  Static Remote   -------    0         -------
127       ----      ----      ----    e8c5.7aff.96de   29.29.29.29                  Static Remote   -------    0         -------
```

```
Total number of entries are 4

#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
127      98.98.101.1      0011.2233.4455 Static Local   ----
127      99.99.101.1      0011.2233.4567 Static Remote  ----
127      103.103.102.1    e49d.73b3.c101 Static Local   ----
127      103.103.103.1    e8c5.7aff.96de  Static Remote  ----
127      104.104.103.1    0011.2233.4455 Static Local   ----
127      104.104.104.1    0011.2233.4567 Static Remote  ----
Total number of entries are 6
```

PE2 verification:

```
#show evpn mpls mac-table
=================================================================================================================================
                                                    EVPN MPLS MAC Entries
=================================================================================================================================
VNID      Interface VlanId    In-VlanId Mac-Addr       VTEP-Ip/ESI                    Type           Status     MAC move AccessPortDesc
_________________________________________________________________________________________________________________________________
127       ----      ----      ----      0011.2233.4455 22.22.22.22                   Static Remote   -------    0        -------
127       irb127    ----      ----      0011.2233.4567 29.29.29.29                   Static Local    -------    0        -------
127       ----      ----      ----      e49d.73b3.c101 22.22.22.22                   Static Remote   -------    0        -------
127       irb127    ----      ----      e8c5.7aff.96de 29.29.29.29                   Static Local    -------    0        -------

Total number of entries are : 4

#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
ARP Timeout :  180 sec   Random-Jitter-Max : 200

EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
127      98.98.101.1      0011.2233.4455 Static Remote  ----
127      99.99.101.1      0011.2233.4567 Static Local   ----
127      103.103.102.1    e49d.73b3.c101 Static Remote  ----
127      103.103.103.1    e8c5.7aff.96de Static Local   ----
127      104.104.103.1    0011.2233.4455 Static Remote  ----
127      104.104.104.1    0011.2233.4567 Static Local   ----
```

Verify EVPN route count information as per VPN-ID or Route type:

PE1 verification:

```
#show evpn mpls route-count
EVPN-MPLS Active route count information
====================================
Max supported route count   : 131072
Active route count: 8

--------------------------------------------
 VNID     Total    MACONLY  MACIPv4  MACIPv6
```

```
---------------------------------------------
127             8           0                  6          2
```

PE2 verification:

```
#show evpn mpls route-count
EVPN-MPLS Active route count information
====================================
Max supported route count   : 131072
Active route count: 8

---------------------------------------------
 VNID     Total    MACONLY  MACIPv4  MACIPv6
--------------------------------------
 127             8           0                  6          2
```

Verify in the BGP EVPN table:

PE1 Verification:

```
#show bgp l2vpn evpn
BGP table version is 2, local router ID is 22.22.22.22
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

    Network          Next Hop            Metric    LocPrf       Weight     Path  Peer          Encap

RD[10:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[17]
                      29.29.29.29         0       100       0    ?  29.29.29.29     MPLS

RD[20:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                      10.10.10.10         0       100       0    ?  10.10.10.10     MPLS

RD[10.10.10.10:123]
*>i  [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[22]
                      10.10.10.10         0       100       0    i  10.10.10.10     MPLS
*>i  [3]:[123]:[32,10.10.10.10]
                      10.10.10.10         0       100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:124]
*>i  [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[24]
                      10.10.10.10         0       100       0    i  10.10.10.10     MPLS
*>i  [3]:[124]:[32,10.10.10.10]
                      10.10.10.10         0       100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:125]
*>i  [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[21]
                      10.10.10.10         0       100       0    i  10.10.10.10     MPLS
*>i  [3]:[125]:[32,10.10.10.10]
```

```
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:126]
*>i  [3]:[126]:[32,10.10.10.10]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:205]
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][26]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS
*>i  [3]:[127]:[32,10.10.10.10]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:305]
*>i  [5]:[0]:[0]:[24]:[99.99.101.0]:[0.0.0.0]:[17]
                     10.10.10.10          0        100       0    ?  10.10.10.10     MPLS
*>i  [5]:[0]:[0]:[24]:[103.103.103.0]:[0.0.0.0]:[17]
                     10.10.10.10          0        100       0    ?  10.10.10.10     MPLS
*>i  [5]:[0]:[0]:[24]:[104.104.104.0]:[0.0.0.0]:[17]
                     10.10.10.10          0        100       0    ?  10.10.10.10     MPLS

RD[10.10.10.10:333]
*>i  [5]:[0]:[0]:[24]:[99.99.99.0]:[0.0.0.0]:[19]
                     10.10.10.10          0        100       0    ?  10.10.10.10     MPLS

RD[10.10.10.10:334]
*>i  [5]:[0]:[0]:[24]:[99.99.100.0]:[0.0.0.0]:[18]
                     10.10.10.10          0        100       0    ?  10.10.10.10     MPLS

RD[10.10.10.10:500]
*>i  [3]:[500]:[32,10.10.10.10]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS

RD[22.22.22.22:123] VRF[vrf100_mgmt]:
*>   [2]:[0]:[123]:[48,0011:2233:4455]:[32,98.98.98.1]:[25618]
                     22.22.22.22          0        100       32768  i  ----------    MPLS
* i  [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[28]
                     29.29.29.29          0        100       0    i  29.29.29.29     MPLS
* i                  10.10.10.10          0        100       0    i  10.10.10.10     MPLS
* i  [3]:[123]:[32,10.10.10.10]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS
*>   [3]:[123]:[32,22.22.22.22]
                     22.22.22.22          0        100       32768  i  ----------    MPLS
* i  [3]:[123]:[32,29.29.29.29]
                     29.29.29.29          0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:124] VRF[vrf200_mgmt]:
*>   [2]:[0]:[124]:[48,0011:2233:4455]:[32,98.98.99.1]:[25619]
                     22.22.22.22          0        100       32768  i  ----------    MPLS
* i  [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[29]
                     29.29.29.29          0        100       0    i  29.29.29.29     MPLS
* i                  10.10.10.10          0        100       0    i  10.10.10.10     MPLS
* i  [3]:[124]:[32,10.10.10.10]
                     10.10.10.10          0        100       0    i  10.10.10.10     MPLS
*>   [3]:[124]:[32,22.22.22.22]
                     22.22.22.22          0        100       32768  i  ----------    MPLS
* i  [3]:[124]:[32,29.29.29.29]
                     29.29.29.29          0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:125] VRF[vrf201_mgmt]:
*>   [2]:[0]:[125]:[48,0011:2233:4455]:[32,88.88.1.1]:[25629]
                     22.22.22.22          0        100       32768  i  ----------    MPLS
* i  [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[37]
                     29.29.29.29          0        100       0    i  29.29.29.29     MPLS
* i                  10.10.10.10          0        100       0    i  10.10.10.10     MPLS
* i  [3]:[125]:[32,10.10.10.10]
```

```
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [3]:[125]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
* i  [3]:[125]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:126] VRF[vrf202_mgmt]:
* i  [3]:[126]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [3]:[126]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
* i  [3]:[126]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:200] VRF[blue]:
*>   [2]:[0]:[200]:[48,e49d:73b3:c101]:[32,70.70.1.1]:[25636]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
*>   [3]:[200]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------     MPLS

RD[22.22.22.22:205] VRF[vrf205_mgmt]:
*>   [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------     MPLS
*>   [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i  [3]:[127]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [3]:[127]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
* i  [3]:[127]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:500] VRF[ELAN_vrf500]:
* i  [3]:[500]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [3]:[500]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
* i  [3]:[500]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:501] VRF[ELAN_vrf501]:
*>   [3]:[501]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
* i  [3]:[501]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:502] VRF[ELAN_vrf502]:
*>   [3]:[502]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------    MPLS
* i  [3]:[502]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[22.22.22.22:503] VRF[ELAN_vrf503]:
*>   [3]:[503]:[32,22.22.22.22]
```

```
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[503]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:504] VRF[ELAN_vrf504]:
*>   [3]:[504]:[32,22.22.22.22]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[504]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:505] VRF[ELAN_vrf505]:
*>   [3]:[505]:[32,22.22.22.22]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[505]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:506] VRF[ELAN_vrf506]:
*>   [3]:[506]:[32,22.22.22.22]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[506]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:507] VRF[ELAN_vrf507]:
*>   [3]:[507]:[32,22.22.22.22]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[507]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:508] VRF[ELAN_vrf508]:
*>   [3]:[508]:[32,22.22.22.22]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[508]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:509] VRF[ELAN_vrf509]:
*>   [3]:[509]:[32,22.22.22.22]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[509]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:510] VRF[ELAN_vrf510]:
*>   [3]:[510]:[32,22.22.22.22]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
* i  [3]:[510]:[32,29.29.29.29]
                      29.29.29.29        0        100       0    i  29.29.29.29    MPLS

RD[22.22.22.22:600] VRF[eline600]:
*>   [1]:[0]:[600]:[25628]
                      22.22.22.22        0        100       32768  i  ----------    MPLS

RD[22.22.22.22:602] VRF[eline602]:
*>   [1]:[0]:[602]:[25635]
                      22.22.22.22        0        100       32768  i  ----------    MPLS

RD[22.22.22.22:604] VRF[eline604]:
*>   [1]:[0]:[604]:[25631]
                      22.22.22.22        0        100       32768  i  ----------    MPLS

RD[22.22.22.22:606] VRF[eline606]:
*>   [1]:[0]:[606]:[25634]
                      22.22.22.22        0        100       32768  i  ----------    MPLS

RD[22.22.22.22:608] VRF[eline608]:
*>   [1]:[0]:[608]:[25613]
                      22.22.22.22        0        100       32768  i  ----------    MPLS

RD[22.22.22.22:610] VRF[eline610]:
*>   [1]:[0]:[610]:[25626]
                      22.22.22.22        0        100       32768  i  ----------    MPLS

RD[22.22.22.22:612] VRF[eline612]:
*>   [1]:[0]:[612]:[25632]
                      22.22.22.22        0        100       32768  i  ----------    MPLS
```

```
RD[22.22.22.22:614] VRF[eline614]:
*>   [1]:[0]:[614]:[25625]
                       22.22.22.22          0        100       32768  i  ----------    MPLS

RD[22.22.22.22:616] VRF[eline616]:
*>   [1]:[0]:[616]:[25612]
                       22.22.22.22          0        100       32768  i  ----------    MPLS

RD[22.22.22.22:618] VRF[eline618]:
*>   [1]:[0]:[618]:[25617]
                       22.22.22.22          0        100       32768  i  ----------    MPLS

RD[22.22.22.22:620] VRF[eline620]:
*>   [1]:[0]:[620]:[25638]
                       22.22.22.22          0        100       32768  i  ----------    MPLS

RD[22.22.22.22:2002] VRF[vrf2002]:
*>   [1]:[0]:[2224]:[25630]
                       22.22.22.22          0        100       32768  i  ----------      MPLS

RD[22.22.22.22:2003] VRF[vrf2003]:
*>   [1]:[0]:[2226]:[25637]
                       22.22.22.22          0        100       32768  i  ----------      MPLS

RD[22.22.22.22:2004] VRF[vrf2004]:
*>   [1]:[0]:[2228]:[25633]
                       22.22.22.22          0        100       32768  i  ----------      MPLS

RD[22.22.22.22:2005] VRF[vrf2005]:
*>   [1]:[0]:[2300]:[25639]
                       22.22.22.22          0        100       32768  i  ----------      MPLS

RD[29.29.29.29:123]
*>i  [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[28]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [3]:[123]:[32,29.29.29.29]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS

RD[29.29.29.29:124]
*>i  [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[29]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [3]:[124]:[32,29.29.29.29]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS

RD[29.29.29.29:125]
*>i  [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[37]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [3]:[125]:[32,29.29.29.29]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS

RD[29.29.29.29:126]
*>i  [3]:[126]:[32,29.29.29.29]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS

RD[29.29.29.29:205]
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][22]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS
*>i  [3]:[127]:[32,29.29.29.29]
                       29.29.29.29          0        100       0    i  29.29.29.29    MPLS

RD[29.29.29.29:305]
*>i  [5]:[0]:[0]:[24]:[99.99.101.0]:[0.0.0.0]:[18]
                       29.29.29.29          0        100       0    ?  29.29.29.29    MPLS
*>i  [5]:[0]:[0]:[24]:[103.103.103.0]:[0.0.0.0]:[18]
```

```
                      29.29.29.29         0        100       0    ?  29.29.29.29     MPLS
*>i  [5]:[0]:[0]:[24]:[104.104.104.0]:[0.0.0.0]:[18]
                      29.29.29.29         0        100       0    ?  29.29.29.29     MPLS

RD[29.29.29.29:333]
*>i  [5]:[0]:[0]:[24]:[99.99.99.0]:[0.0.0.0]:[20]
                      29.29.29.29         0        100       0    ?  29.29.29.29     MPLS

RD[29.29.29.29:334]
*>i  [5]:[0]:[0]:[24]:[99.99.100.0]:[0.0.0.0]:[19]
                      29.29.29.29         0        100       0    ?  29.29.29.29     MPLS

RD[29.29.29.29:500]
*>i  [3]:[500]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:501]
*>i  [3]:[501]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:502]
*>i  [3]:[502]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:503]
*>i  [3]:[503]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:504]
*>i  [3]:[504]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:505]
*>i  [3]:[505]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:506]
*>i  [3]:[506]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:507]
*>i  [3]:[507]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:508]
*>i  [3]:[508]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:509]
*>i  [3]:[509]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:510]
*>i  [3]:[510]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

Total number of prefixes 121
```

PE2 Verification:

```
#show bgp l2vpn evpn
BGP table version is 3, local router ID is 29.29.29.29
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
```

```
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

    Network          Next Hop            Metric    LocPrf       Weight     Path  Peer          Encap

RD[20:200]
*>i  [5]:[0]:[0]:[24]:[80.80.1.0]:[0.0.0.0]:[16]
                      10.10.10.10         0        100       0    ?  10.10.10.10     MPLS

RD[30:200]
*>i  [5]:[0]:[0]:[24]:[70.70.1.0]:[0.0.0.0]:[25600]
                      22.22.22.22         0        100       0    ?  22.22.22.22     MPLS

RD[10.10.10.10:123]
*>i  [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[22]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [3]:[123]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:124]
*>i  [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[24]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [3]:[124]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:125]
*>i  [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[21]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [3]:[125]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:126]
*>i  [3]:[126]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:200]
*>i  [2]:[0]:[100]:[48,d077:ce2a:8001]:[32,80.80.1.1]:[23]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [3]:[100]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:205]
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>i  [3]:[127]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS

RD[10.10.10.10:305]
*>i  [5]:[0]:[0]:[24]:[99.99.101.0]:[0.0.0.0]:[17]
                      10.10.10.10         0        100       0    ?  10.10.10.10     MPLS
*>i  [5]:[0]:[0]:[24]:[103.103.103.0]:[0.0.0.0]:[17]
                      10.10.10.10         0        100       0    ?  10.10.10.10     MPLS
*>i  [5]:[0]:[0]:[24]:[104.104.104.0]:[0.0.0.0]:[17]
                      10.10.10.10         0        100       0    ?  10.10.10.10     MPLS

RD[10.10.10.10:333]
*>i  [5]:[0]:[0]:[24]:[99.99.99.0]:[0.0.0.0]:[19]
                      10.10.10.10         0        100       0    ?  10.10.10.10     MPLS
```

```
RD[10.10.10.10:334]
*>i  [5]:[0]:[0]:[24]:[99.99.100.0]:[0.0.0.0]:[18]
                      10.10.10.10         0        100       0    ?  10.10.10.10     MPLS

RD[10.10.10.10:500]
*>i  [3]:[500]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS

RD[22.22.22.22:123]
*>i  [2]:[0]:[123]:[48,0011:2233:4455]:[32,98.98.98.1]:[25618]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>i  [3]:[123]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:124]
*>i  [2]:[0]:[124]:[48,0011:2233:4455]:[32,98.98.99.1]:[25619]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>i  [3]:[124]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:125]
*>i  [2]:[0]:[125]:[48,0011:2233:4455]:[32,88.88.1.1]:[25629]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>i  [3]:[125]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:126]
*>i  [3]:[126]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:205]
*>i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>i  [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>i  [3]:[127]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:305]
*>i  [5]:[0]:[0]:[24]:[98.98.101.0]:[0.0.0.0]:[25601]
                      22.22.22.22         0        100       0    ?  22.22.22.22     MPLS
*>i  [5]:[0]:[0]:[24]:[103.103.102.0]:[0.0.0.0]:[25601]
                      22.22.22.22         0        100       0    ?  22.22.22.22     MPLS
*>i  [5]:[0]:[0]:[24]:[104.104.103.0]:[0.0.0.0]:[25601]
                      22.22.22.22         0        100       0    ?  22.22.22.22     MPLS

RD[22.22.22.22:333]
*>i  [5]:[0]:[0]:[24]:[98.98.98.0]:[0.0.0.0]:[25606]
                      22.22.22.22         0        100       0    ?  22.22.22.22     MPLS

RD[22.22.22.22:334]
*>i  [5]:[0]:[0]:[24]:[98.98.99.0]:[0.0.0.0]:[25605]
                      22.22.22.22         0        100       0    ?  22.22.22.22     MPLS

RD[22.22.22.22:335]
*>i  [5]:[0]:[0]:[24]:[88.88.1.0]:[0.0.0.0]:[25604]
                      22.22.22.22         0        100       0    ?  22.22.22.22     MPLS

RD[22.22.22.22:500]
*>i  [3]:[500]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:501]
*>i  [3]:[501]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:502]
*>i  [3]:[502]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:503]
```

```
*>i  [3]:[503]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:504]
*>i  [3]:[504]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:505]
*>i  [3]:[505]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:506]
*>i  [3]:[506]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:507]
*>i  [3]:[507]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:508]
*>i  [3]:[508]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:509]
*>i  [3]:[509]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[22.22.22.22:510]
*>i  [3]:[510]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS

RD[29.29.29.29:123] VRF[vrf100_mgmt]:
* i  [2]:[0]:[123]:[48,0011:2233:4455]:[32,98.98.98.1]:[25618]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[123]:[48,0011:2233:4567]:[32,99.99.99.1]:[22]
                       10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                     29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [3]:[123]:[32,10.10.10.10]
                       10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [3]:[123]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[123]:[32,29.29.29.29]
                       29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:124] VRF[vrf200_mgmt]:
* i  [2]:[0]:[124]:[48,0011:2233:4455]:[32,98.98.99.1]:[25619]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[124]:[48,0011:2233:4567]:[32,99.99.100.1]:[24]
                       10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                     29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [3]:[124]:[32,10.10.10.10]
                       10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [3]:[124]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[124]:[32,29.29.29.29]
                       29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:125] VRF[vrf201_mgmt]:
* i  [2]:[0]:[125]:[48,0011:2233:4455]:[32,88.88.1.1]:[25629]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[125]:[48,0011:2233:4567]:[32,88.88.3.1]:[21]
                       10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                     29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [3]:[125]:[32,10.10.10.10]
                       10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [3]:[125]:[32,22.22.22.22]
                       22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[125]:[32,29.29.29.29]
                       29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:126] VRF[vrf202_mgmt]:
* i  [3]:[126]:[32,10.10.10.10]
                       10.10.10.10         0        100       0    i  10.10.10.10     MPLS
```

```
* i  [3]:[126]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[126]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:200] VRF[blue]:
* i  [2]:[0]:[100]:[48,d077:ce2a:8001]:[32,80.80.1.1]:[23]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [2]:[0]:[100]:[48,e8c5:7aff:96de]:[32,80.80.1.1]:[38]
                      29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [3]:[100]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [3]:[100]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:205] VRF[vrf205_mgmt]:
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                    29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                    29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                    29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
                      29.29.29.29         0        100       32768  i  ----------    MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
                      29.29.29.29         0        100       32768  i  ----------    MPLS
* i  [3]:[127]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [3]:[127]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[127]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:500] VRF[ELAN_vrf500]:
* i  [3]:[500]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [3]:[500]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[500]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:501] VRF[ELAN_vrf501]:
* i  [3]:[501]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[501]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:502] VRF[ELAN_vrf502]:
* i  [3]:[502]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[502]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:503] VRF[ELAN_vrf503]:
* i  [3]:[503]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[503]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------    MPLS

RD[29.29.29.29:504] VRF[ELAN_vrf504]:
```

```
* i  [3]:[504]:[32,22.22.22.22]
                     22.22.22.22        0        100       0    i  22.22.22.22     MPLS
*>   [3]:[504]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

RD[29.29.29.29:505] VRF[ELAN_vrf505]:
* i  [3]:[505]:[32,22.22.22.22]
                     22.22.22.22        0        100       0    i  22.22.22.22     MPLS
*>   [3]:[505]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

RD[29.29.29.29:506] VRF[ELAN_vrf506]:
* i  [3]:[506]:[32,22.22.22.22]
                     22.22.22.22        0        100       0    i  22.22.22.22     MPLS
*>   [3]:[506]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

RD[29.29.29.29:507] VRF[ELAN_vrf507]:
* i  [3]:[507]:[32,22.22.22.22]
                     22.22.22.22        0        100       0    i  22.22.22.22     MPLS
*>   [3]:[507]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

RD[29.29.29.29:508] VRF[ELAN_vrf508]:
* i  [3]:[508]:[32,22.22.22.22]
                     22.22.22.22        0        100       0    i  22.22.22.22     MPLS
*>   [3]:[508]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

RD[29.29.29.29:509] VRF[ELAN_vrf509]:
* i  [3]:[509]:[32,22.22.22.22]
                     22.22.22.22        0        100       0    i  22.22.22.22     MPLS
*>   [3]:[509]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

RD[29.29.29.29:510] VRF[ELAN_vrf510]:
* i  [3]:[510]:[32,22.22.22.22]
                     22.22.22.22        0        100       0    i  22.22.22.22     MPLS
*>   [3]:[510]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

RD[29.29.29.29:650] VRF[vrf650]:
*>   [3]:[650]:[32,29.29.29.29]
                     29.29.29.29        0        100       32768  i  ----------    MPLS

Total number of prefixes 110
```

Verify the specific type of EVPN routes using VRF:

PE1:

```
#show bgp l2vpn evpn vrf vrf205_mgmt
BGP table version is 1, local router ID is 22.22.22.22
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route
```

```
    Network          Next Hop           Metric    LocPrf       Weight     Path  Peer          Encap
*>   [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
*>   [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i  [3]:[127]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [3]:[127]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
* i  [3]:[127]:[32,29.29.29.29]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS

Total number of prefixes 13
```

PE2:

```
#show bgp l2vpn evpn vrf vrf205_mgmt
BGP table version is 1, local router ID is 29.29.29.29
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

    Network          Next Hop           Metric    LocPrf       Weight     Path  Peer          Encap
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                    29.29.29.29         0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                    29.29.29.29         0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>                    29.29.29.29         0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
```

```
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
                      29.29.29.29         0        100       32768  i  ----------      MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
                      29.29.29.29         0        100       32768  i  ----------      MPLS
* i  [3]:[127]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [3]:[127]:[32,22.22.22.22]
                      22.22.22.22         0        100       0    i  22.22.22.22     MPLS
*>   [3]:[127]:[32,29.29.29.29]
                      29.29.29.29         0        100       32768  i  ----------      MPLS

Total number of prefixes 13
```

Verify the specific type of EVPN routes using RD:

PE1:

```
#show bgp l2vpn evpn rd 22.22.22.22:205
BGP table version is 2, local router ID is 22.22.22.22
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

    Network          Next Hop            Metric     LocPrf       Weight     Path  Peer          Encap

RD[22.22.22.22:205] VRF[vrf205_mgmt]:
*>   [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
*>   [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i                   10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i  [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
                      29.29.29.29         0        100       0    i  29.29.29.29     MPLS
* i  [3]:[127]:[32,10.10.10.10]
                      10.10.10.10         0        100       0    i  10.10.10.10     MPLS
*>   [3]:[127]:[32,22.22.22.22]
                      22.22.22.22         0        100       32768  i  ----------      MPLS
* i  [3]:[127]:[32,29.29.29.29]
```

```
                    29.29.29.29         0       100       0    i  29.29.29.29     MPLS

Total number of prefixes 13
```

PE2:

```
#show bgp l2vpn evpn rd 29.29.29.29:205
BGP table version is 3, local router ID is 29.29.29.29
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network          Next Hop            Metric    LocPrf       Weight     Path  Peer          Encap

RD[29.29.29.29:205] VRF[vrf205_mgmt]:
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,98.98.101.1]:[25608]
                    22.22.22.22         0       100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4455]:[32,104.104.103.1]:[25608]
                    22.22.22.22         0       100       0    i  22.22.22.22     MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,99.99.101.1]:[26]
                    10.10.10.10         0       100       0    i  10.10.10.10     MPLS
*>                  29.29.29.29         0       100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[32,104.104.104.1]:[26]
                    10.10.10.10         0       100       0    i  10.10.10.10     MPLS
*>                  29.29.29.29         0       100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,0011:2233:4567]:[128,1000::1][26]
                    10.10.10.10         0       100       0    i  10.10.10.10     MPLS
*>                  29.29.29.29         0       100       32768  i  ----------      MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[32,103.103.103.1]:[26]
                    10.10.10.10         0       100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,d077:ce2a:8001]:[128,1100::1][26]
                    10.10.10.10         0       100       0    i  10.10.10.10     MPLS
* i  [2]:[0]:[127]:[48,e49d:73b3:c101]:[32,103.103.102.1]:[25608]
                    22.22.22.22         0       100       0    i  22.22.22.22     MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[32,103.103.103.1]:[22]
                    29.29.29.29         0       100       32768  i  ----------      MPLS
*>   [2]:[0]:[127]:[48,e8c5:7aff:96de]:[128,1100::1][22]
                    29.29.29.29         0       100       32768  i  ----------      MPLS
* i  [3]:[127]:[32,10.10.10.10]
                    10.10.10.10         0       100       0    i  10.10.10.10     MPLS
* i  [3]:[127]:[32,22.22.22.22]
                    22.22.22.22         0       100       0    i  22.22.22.22     MPLS
*>   [3]:[127]:[32,29.29.29.29]
                    29.29.29.29         0       100       32768  i  ----------      MPLS

Total number of prefixes 13
```

Verify the specific type of EVPN routes using Prefix:

PE1:

```
#show bgp l2vpn evpn prefix [3]:[127]:[32,29.29.29.29]
BGP table version is 2, local router ID is 22.22.22.22
```

```
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

    Network          Next Hop            Metric    LocPrf       Weight     Path  Peer          Encap

RD[22.22.22.22:205] VRF[vrf205_mgmt]:
* i  [3]:[127]:[32,29.29.29.29]
                       29.29.29.29          0        100       0    i  29.29.29.29     MPLS

RD[29.29.29.29:205]
*>i  [3]:[127]:[32,29.29.29.29]
                       29.29.29.29          0        100       0    i  29.29.29.29     MPLS

Total number of prefixes 2
```

PE2:

```
#show bgp l2vpn evpn prefix [3]:[127]:[32,22.22.22.22]
BGP table version is 3, local router ID is 29.29.29.29
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

    Network          Next Hop            Metric    LocPrf       Weight     Path  Peer          Encap

RD[22.22.22.22:205]
*>i  [3]:[127]:[32,22.22.22.22]
                       22.22.22.22          0        100       0    i  22.22.22.22     MPLS

RD[29.29.29.29:205] VRF[vrf205_mgmt]:
* i  [3]:[127]:[32,22.22.22.22]
                       22.22.22.22          0        100       0    i  22.22.22.22     MPLS

Total number of prefixes 2
```

Verify the specific type of EVPN routes using both VRF and Prefix:

PE1:

```
#show bgp l2vpn evpn vrf vrf205_mgmt  prefix [3]:[127]:[32,29.29.29.29]
BGP table version is 1, local router ID is 22.22.22.22
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network                      Next Hop          Metric    LocPrf    Weight     Path   Peer            Encap
* i  [3]:[127]:[32,29.29.29.29]  29.29.29.29         0        100       0          i    29.29.29.29     MPLS

Total number of prefixes 1
```

PE2:

```
#show bgp l2vpn evpn vrf vrf205_mgmt  prefix [3]:[127]:[32,22.22.22.22]
BGP table version is 1, local router ID is 29.29.29.29
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevant route information]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

   Network                      Next Hop          Metric    LocPrf      Weight     Path   Peer            Encap
* i  [3]:[127]:[32,22.22.22.22]  22.22.22.22         0          100         0          i     22.22.22.22     MPLS

Total number of prefixes 1
```

Verify detailed information of EVPN routes:

PE1:

```
#show bgp l2vpn evpn vrf vrf205_mgmt  prefix [3]:[127]:[32,29.29.29.29] detail

BGP route entry for prefix : [3]:[127]:[32,29.29.29.29]
 Route-Distinguisher: [29.29.29.29:205]
 Flags : Valid, IBGP
 Nexthop : 29.29.29.29  MED value : 0
 Community:
```

```
 Extended Community: RT:65535:1073741951  Encapsulation:MPLS
 Weight :0,  Local Preference :100
 AS Path : Local
 Origin : IGP
 Last Update : Mon Oct  9 10:14:47 2023
 Peer : 29.29.29.29

Total number of prefixes 1
```

PE2:

```
#show bgp l2vpn evpn vrf vrf205_mgmt  prefix [3]:[127]:[32,22.22.22.22] detail

BGP route entry for prefix : [3]:[127]:[32,22.22.22.22]
 Route-Distinguisher: [22.22.22.22:205]
 Flags : Valid, IBGP
 Nexthop : 22.22.22.22  MED value : 0
 Community:
 Extended Community: RT:65535:1073741951  Encapsulation:MPLS
 Weight :0,  Local Preference :100
 AS Path : Local
 Origin : IGP
 Last Update : Mon Apr 15 07:05:47 2019
 Peer : 22.22.22.22
```

Abbreviations

Acronym	Description
VNID	L2 Virtual Network Identifier
VRF	Virtual Routing and Forwarding
EVPN-IRB	Ethernet VPN Integrated Routing and Bridging
MAC	Media Access Control address

CHAPTER 10 CFM over EVPN-MPLS for ELINE MultiHoming

Overview

The Connectivity Fault Management (CFM) enhances the product offering for the Ethernet LINE (ELINE) services in MultiHoming scenarios. Based on the 802.1ag standard, CFM encompasses Continuity Check Message (CCM), Ping, and Trace functions that help in network fault detection and isolation. This feature extends CFM over EVPN-MPLS from being solely for Single-Homing deployments to a MultiHoming scenario, where a Remote Maintenance End Point (R-MEP) is treated as a single instance by MultiHoming peers.

The Topology illustrates the configuration of User-to-Provider (UP) MEP on PE2 and PE3 Access Circuit (AC) ports, along with the corresponding UP MEP configured on the remote AC port (PE1). This configuration results in the establishment of a CFM session between the PE VTEPs and the remote VTEP.

Feature Characteristics

Functional requirements for CFM over ELINE MultiHoming:

Continuity Check Message

Continuity Check Message (CCM) provides the following capabilities:

- Ensures error-free base configuration for EVPN-MPLS MultiHoming.
- Maintains uniformity of R-MEP and remote-MAC on MultiHoming nodes.
- Enables the data plane to notify the control plane of CCM timeout, port/interface state changes, and Remote Defect Indication (RDI).
- Configures the data plane to send and process CCMs at specified intervals, with options to enable/disable CCM transmission.
- Detects connectivity failures when no CCM frames are received within a set interval and notifies the control plane.
- Programs the data plane to include Port and Interface Status Type-Length-Values (TLVs) in transmitted CCM frames.
- Transmits CC Protocol Data Unit (PDU) frames with IEEE 802.1ag-2007 compliance and supports RDI bit set or reset operations.

Ping and Trace

Ping and Trace provide the following capabilities:

- Facilitates data plane snooping of LBM or Linktrace Message (LTM) received on MEP.
- Traps LTR PDUs received on MEP and processes/replies to LBM received on User-to-Provider (UP) MEP.
- Uplifts CFM PDUs from the data plane to the control plane, and sends CFM PDUs from the control plane to the data plane.
- Provides statistics counters for transmitted Loopback Replies (LBR) and encodes service frame counts in LBM and LBR PDUs.

Benefits

Enhanced Network Monitoring: CFM enables continuous monitoring of network connections, providing real-time insights into connectivity status and performance. This ensures that any issues are quickly detected and addressed.

Quick Fault Detection: Through CCM, the system promptly identifies any disruptions or faults in the network. This swift detection allows for rapid response and minimized downtime.

Efficient Troubleshooting: CFM's Ping and Trace functions help troubleshoot network problems by pinpointing the origin of issues and the paths taken by data packets. This capability streamlines the resolution process.

Robust MultiHoming Support: The extension of CFM support to MultiHoming scenarios ensures that complex network setups remain resilient and well-monitored, even in challenging environments.

Prerequisites

Before configuring and utilizing CFM for ELINE MultiHoming, ensure the following prerequisites are met:

- **Hardware Profiles Configuration**
  - Enable the required hardware profiles to facilitate CFM operations. These include `cfm-domain-name-str`, `cfm-ccm`, and `evpn-mpls-mh` profiles.
  - Establish the hardware-profile filter (`evpn-mpls-mh)` for EVPN-MPLS MultiHoming.
- **EVPN-MPLS Configuration**
  - Enable and configure EVPN MPLS on the relevant devices and enable MultiHoming support within EVPN MPLS.
- **ELINE Service Setup**
  - Establish the ELINE service and assign the corresponding VPN identifiers (VPN-ID).
  - Configure the host-reachability-protocol using EVPN BGP with the associated Virtual Routing and Forwarding (VRF).
- **ELINE AC MultiHoming Configuration**
  - Configure ELINE MultiHoming features with proper encapsulation settings (e.g., `dot1q`) and `access-if-evpn` settings on relevant interfaces.
  - Define the necessary mapping of VPN identifiers (VPN-ID) for the EVPN service.

For more information on the EVPN MPLS configurations, refer to the EVPN MPLS Configuration and EVPN MPLS Commands chapters in the *Multi-Protocol Label Switching Guide*.

- **MAC and MEP Considerations**
  - Ensure that the MEP on MultiHoming nodes has the same MAC. Consistent Media Access Control (MAC) addressing across Access Circuit (AC) ports is essential to facilitate single R-MEP consideration on MultiHoming peers.

For more information on the CFM configurations, refer to the Carrier Ethernet configuration section and CFM and Y.1731 Commands chapters in the *Carrier Ethernet Guide*.

Meeting these prerequisites ensures a successful setup of CFM for ELINE MultiHoming, enabling enhanced network fault detection and isolation capabilities.

Configuration

This section illustrates the MultiHomed setup for the CFM over EVPN MPLS feature, showcasing examples for ELINE services with LDP as the underlay MPLS path.

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Topology

Figure 10-2 consists of customer edge routers CE1 and CE2, and with IPv4 Provider Edge routers PE1, PE2, and PE3, all interconnected through the core router P in the IPv4 MPLS provider network.

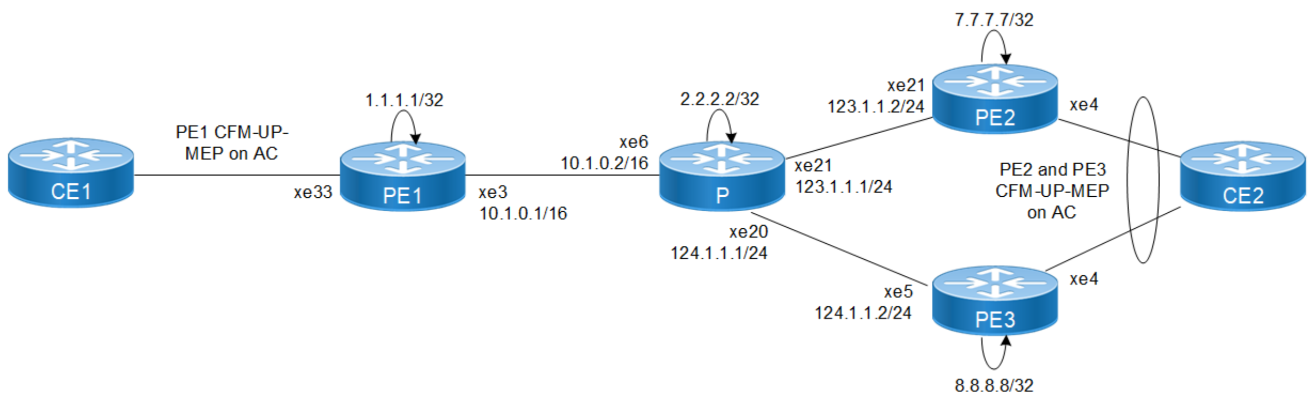

Figure 10-2: CFM over EVPN-MPLS for ELINE MH configuration

CFM Configuration

To enhance network management, monitoring, performance, and fault detection, configure the following hardware-profile commands on PE1, PE2, and PE3 devices, and here are the steps for the configurations: PE1: CFM and PE2/PE3: CFM.

- Enable the filter for CFM domain name strings with the command `hardware-profile filter cfm-domain-name-str enable`. This filter enhances the network devices ability to process CFM domain name strings, facilitating better network management and service identification.
- Enable statistics collection for CFM Continuity Check Messages (CCM) using the command `hardware-profile statistics cfm-ccm enable`. This feature allows the network devices to gather valuable insights into network performance and fault detection by collecting and analyzing data related to CFM CCMs.

PE1: Loopback Interface

The configuration on PE1 for a loopback interface with IP address `1.1.1.1/32` secondary is set up to provide IP connectivity for the router.

`PE1#configure terminal`	Enter configure mode.
`PE1(config)#interface lo`	Enter the interface mode for the loopback interface `lo`.
`PE1(config-if)#ip address 1.1.1.1/32 secondary`	Configure a secondary IP address, `1.1.1.1/32`, on the loopback interface.
`PE1(config-if)#exit`	Exit interface mode `lo`.
`PE1(config)#commit`	Commit the transaction.

PE1: Global LDP

The configuration on PE1 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE1(config)#router ldp	Enter the Router LDP mode.
PE1(config-router)#router-id 1.1.1.1	Set the router ID for LDP to 1.1.1.1.
PE1(config-router)#targeted-peer ipv4 7.7.7.7	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#targeted-peer ipv4 8.8.8.8	Configure targeted peer for LDP using IPv4 addresses.
PE1(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE1(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: Global EVPN MPLS Command

The configuration on PE1 for the Global EVPN MPLS includes activating EVPN MPLS defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multihoming, and activating EVPN MPLS multihoming functionality, all of which are crucial for enabling EVPN MPLS features.

PE1(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE1, enabling it to participate in EVPN MPLS services.
PE1(config)#commit	Commit candidate configuration to be running configuration.
PE1(config)#evpn mpls vtep-ip-global 1.1.1.1	Configure the global VTEP IP address 1.1.1.1, associating it with the loopback IP.
PE1(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multihoming.
PE1(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multihoming functionality, allowing PE1 to support multihomed EVPN MPLS services.
PE1(config)#commit	Commit the transaction.

PE1: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE1 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE1(config)#interface xe3	Enter interface mode xe3.
PE1(config-if)#ip address 10.1.0.1/16	Configure an IP address, 10.1.0.1/16, on the interface xe3.
PE1(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE1(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE1(config-if)#exit	Exit interface mode xe3.
PE1(config)#commit	Commit the transaction.

PE1: OSPF Configuration

The below configuration is performed to set up OSPF on PE1, specifying the router ID and defining network interfaces.

`PE1(config)#router ospf 1`	Enter the router OSPF mode. Configure PE1 to run OSPF with process ID 1.
`PE1(config-router)#ospf router-id 1.1.1.1`	Set the OSPF router ID to `1.1.1.1`, identifying PE1 within the OSPF network.
`PE1(config-router)#network 1.1.1.1/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`PE1(config-router)#network 10.1.0.0/16 area 0.0.0.0`	Advertise network address in OSPF.
`PE1(config-router)#exit`	Exit router OSPF mode and return to configure mode.
`PE1(config)#commit`	Commit the transaction.

PE1: BGP Configuration

The below BGP configuration on PE1 is established to enable BGP routing with ASN 1, set the BGP router ID, define iBGP neighbors, and enable the EVPN address family for efficient routing in an EVPN environment.

`PE1(config)#router bgp 1`	Enter the Router BGP mode, ASN: 1
`PE1(config-router)#bgp router-id 1.1.1.1`	Configure BGP router ID `1.1.1.1`, identifying PE1 within the BGP network.
`PE1(config-router)#neighbor 7.7.7.7 remote-as 1`	Configure neighbor `7.7.7.7` as an iBGP neighbor with their remote AS number `1`.
`PE1(config-router)#neighbor 7.7.7.7 update-source lo`	Configure neighbor `7.7.7.7` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#neighbor 8.8.8.8 remote-as 1`	Configure neighbor `8.8.8.8` as an iBGP neighbor with their remote AS number `1`.
`PE1(config-router)#neighbor 8.8.8.8 update-source lo`	Configure neighbor `8.8.8.8` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE1(config-router)#address-family l2vpn evpn`	Enter into address family mode for L2VPN EVPN.
`PE1(config-router-af)#neighbor 7.7.7.7 activate`	Activate EVPN for iBGP neighbor `7.7.7.7` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#neighbor 8.8.8.8 activate`	Activate EVPN for iBGP neighbor `8.8.8.8` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE1(config-router-af)#exit`	Exit address family mode and return to the router BGP mode.
`PE1(config-router)#commit`	Commit the transaction.
`PE1(config-router)#exit`	Exit router BGP mode and return to the configure mode.

PE1: MAC VRF Configuration

The below MAC VRF configuration on PE1 is carried out to define and set up VRF named `vrf2` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

`PE1(config)#mac vrf vrf2`	Enter VRF mode named `vrf2`.
`PE1(config-vrf)#rd 1.1.1.1:2`	Configure Route-Distinguisher value of `1.1.1.1:2`.
`PE1(config-vrf)#route-target both 2:2`	Configure import and export values for the `vrf2` as `2:2`.

PE1(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE1(config)#commit	Commit the transaction.

PE1: EVPN and VRF Mapping

The EVPN and VRF mapping configuration on PE1 establishes mappings between the EVPN identifier and VRF, facilitating efficient routing and connectivity in an EVPN network environment.

PE1(config)#evpn mpls id 52 xconnect target-mpls-id 2	Configure the EVPN-VPWS identifier with a source identifier of 52 and a target identifier of 2.
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Map VRF vrf2 to the EVPN-VPWS identifier
PE1(config-evpn-mpls)#commit	Commit the transaction.
PE1(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE1: Access Port Configuration

The below access port configuration on PE1 is carried out to create a Layer 2 sub-interface within the physical interface, description the interface, configure the encapsulation with VLAN ID, and map VPN-ID for efficient network access and connectivity.

PE1(config)#interface xe33	Enter interface mode xe33.
PE1(config-if)#interface xe33.2 switchport	Create a Layer 2 sub-interface xe33.2 within the physical interface xe33.
PE1(config-if)#description access-side-int	Provide a description for the interface.
PE1(config-if)#encapsulation dot1q 2	Set encapsulation to dot1q with VLAN ID 2.
PE1(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE1(config-acc-if-evpn)#map vpn-id 52	Map VPN-ID 52.
PE1(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE1(config-if)#exit	Exit interface mode xe33 and return to the configure mode.
PE1(config)#commit	Commit the transaction.

P: Loopback Interface

The configuration on P for a loopback interface with IP address 2.2.2.2/32 secondary is set up to provide IP connectivity for the router.

P#configure terminal	Enter configure mode.
P(config)#interface lo	Enter the interface mode for the loopback interface lo.
P(config-if)#ip address 2.2.2.2/32 secondary	Configure a secondary IP address, 2.2.2.2/32, on the loopback interface.
P(config-if)#exit	Exit interface mode lo.
P(config)#commit	Commit the transaction.

P: Global LDP

The configuration on P for the Global LDP router, specifying router ID to set up Label Distribution Protocol (LDP) settings for MPLS.

`P(config)#router ldp`	Enter the Router LDP mode.
`P(config-router)#router-id 2.2.2.2`	Set the router ID for LDP to `2.2.2.2`.
`P(config-router)#exit`	Exit router LDP mode and return to the configure mode.
`P(config)#commit`	Commit the transaction.

P: Interface Configuration

The below configuration is performed to set up interfaces on P and enable LDP for IPv4, ensuring proper routing and labeling functionality.

`P(config)#interface xe6`	Enter interface mode `xe6`.
`P(config-if)#ip address 10.1.0.2/16`	Configure an IP address, `10.1.0.2/16`, on the interface `xe6`.
`P(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P(config-if)#exit`	Exit interface mode `xe6`.
`P(config)#commit`	Commit the transaction.
`P(config)#interface xe21`	Enter interface mode `xe21`.
`P(config-if)#ip address 123.1.1.1/24`	Configure an IP address, `123.1.1.1/24`, on the interface `xe21`.
`P(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P(config-if)#exit`	Exit interface mode `xe21`.
`P(config)#commit`	Commit the transaction.
`P(config)#interface xe20`	Enter interface mode `xe20`.
`P(config-if)#ip address 124.1.1.1/24`	Configure an IP address, `124.1.1.1/24`, on the interface `xe20`.
`P(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`P(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`P(config-if)#exit`	Exit interface mode `xe20`.
`P(config)#commit`	Commit the transaction.

P: OSPF Configuration

The below configuration is performed to set up OSPF on P, specifying the router ID and defining network interfaces for efficient routing.

`P(config)#router ospf 1`	Enter the router OSPF mode. Configure P to run OSPF with process ID `1`.
`P(config-router)#ospf router-id 2.2.2.2`	Set the OSPF router ID to `2.2.2.2`, identifying P within the OSPF network.
`P(config-router)#network 2.2.2.2/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`P(config-router)#network 10.1.0.2/16 area 0.0.0.0`	Advertise network address in OSPF.
`P(config-router)#network 123.1.1.1/24 area 0.0.0.0`	Advertise network address in OSPF.
`P(config-router)#network 124.1.1.1/24 area 0.0.0.0`	Advertise network address in OSPF.
`P(config-router)#exit`	Exit router OSPF mode and return to the configure mode.
`P(config)#commit`	Commit the transaction.

PE2: Loopback Interface

The configuration on PE2 for a loopback interface with IP address `7.7.7.7/32` secondary is set up to provide IP connectivity for the router.

`PE2#configure terminal`	Enter configure mode.
`PE2(config)#interface lo`	Enter the interface mode for the loopback interface `lo`.
`PE2(config-if)#ip address 7.7.7.7/32 secondary`	Configure a secondary IP address, `7.7.7.7/32`, on the loopback interface.
`PE2(config-if)#exit`	Exit interface mode `lo`.
`PE2(config)#commit`	Commit the transaction.

PE2: Global LDP

The configuration on PE2 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

`PE2(config)#router ldp`	Enter the Router LDP mode.
`PE2(config-router)#router-id 7.7.7.7`	Set the router ID for LDP to `7.7.7.7`.
`PE2(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted peer for LDP using IPv4 addresses.
`PE2(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit router targeted-peer-mode.
`PE2(config-router)#targeted-peer ipv4 8.8.8.8`	Configure targeted peer for LDP using IPv4 addresses.
`PE2(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit router targeted-peer-mode.
`PE2(config-router)#exit`	Exit router LDP mode and return to the configure mode.
`PE2(config)#commit`	Commit the transaction.

PE2: Global EVPN MPLS Command

The configuration on PE2 for the Global EVPN MPLS, includes activating EVPN MPLS defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multihoming, and activating EVPN MPLS multihoming functionality, all of which are crucial for enabling EVPN MPLS features.

`PE2(config)#evpn mpls enable`	Activate the EVPN MPLS functionality on `PE2`, enabling it to participate in EVPN MPLS services.
`PE2(config)#commit`	Commit candidate configuration to be running configuration.
`PE2(config)#evpn mpls vtep-ip-global 7.7.7.7`	Configure the global VTEP IP address `7.7.7.7`, associating it with the loopback IP.
`PE2(config)#hardware-profile filter evpn-mpls-mh enable`	Enable hardware-profile filter for EVPN MPLS multihoming.
`PE2(config)#evpn mpls multihoming enable`	Activate the EVPN MPLS multihoming functionality, allowing `PE2` to support multihomed EVPN MPLS services.
`PE2(config)#commit`	Commit the transaction.

PE2: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE2 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

`PE2(config)#interface xe21`	Enter interface mode `xe21`.
`PE2(config-if)#ip address 123.1.1.2/24`	Configure an IP address, `123.1.1.2/24`, on the interface `xe21`.
`PE2(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
`PE2(config-if)#label-switching`	Enable label switching on the interface to enable MPLS-based packet forwarding.
`PE2(config-if)#exit`	Exit interface mode `xe21`.
`PE2(config)#commit`	Commit the transaction.

PE2: OSPF Configuration

The below configuration is performed to set up OSPF on PE2, specifying the router ID and defining network interfaces.

`PE2(config)#router ospf 1`	Enter the router OSPF mode. Configure PE2 to run OSPF with process ID 1.
`PE2(config-router)#ospf router-id 7.7.7.7`	Set the OSPF router ID to `7.7.7.7`, identifying PE2 within the OSPF network.
`PE2(config-router)#network 7.7.7.7/32 area 0.0.0.0`	Advertise loopback address in OSPF.
`PE2(config-router)#network 123.1.1.0/24 area 0.0.0.0`	Advertise network address in OSPF.
`PE2(config-router)#exit`	Exit router OSPF mode and return to configure mode.
`PE2(config)#commit`	Commit the transaction.

PE2: BGP Configuration

The below BGP configuration on PE2 is established to enable BGP routing with ASN 1, set the BGP router ID, define iBGP neighbors, and enable the EVPN address family for efficient routing in an EVPN environment.

`PE2(config)#router bgp 1`	Enter the Router BGP mode, ASN: 1
`PE2(config-router)#bgp router-id 7.7.7.7`	Configure BGP router ID `7.7.7.7`, identifying PE2 within the BGP network.
`PE2(config-router)#neighbor 1.1.1.1 remote-as 1`	Configure neighbor `1.1.1.1` as an iBGP neighbor with their remote AS number `1`.
`PE2(config-router)#neighbor 1.1.1.1 update-source lo`	Configure neighbor `1.1.1.1` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE2(config-router)#neighbor 8.8.8.8 remote-as 1`	Configure neighbor `8.8.8.8` as an iBGP neighbor with their remote AS number `1`.
`PE2(config-router)#neighbor 8.8.8.8 update-source lo`	Configure neighbor `8.8.8.8` as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
`PE2(config-router)#address-family l2vpn evpn`	Enter into address family mode for L2VPN EVPN.
`PE2(config-router-af)#neighbor 1.1.1.1 activate`	Activate EVPN for iBGP neighbor `1.1.1.1` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE2(config-router-af)#neighbor 8.8.8.8 activate`	Activate EVPN for iBGP neighbor `8.8.8.8` within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
`PE2(config-router-af)#exit`	Exit address family mode and return to the router BGP mode.
`PE2(config-router)#commit`	Commit the transaction.
`PE2(config-router)#exit`	Exit router BGP mode and return to the configure mode.

PE2: MAC VRF Configuration

The below MAC VRF configuration on PE2 is carried out to define and set up VRF named `vrf2` with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

`PE2(config)#mac vrf vrf2`	Enter VRF mode named `vrf2`.
`PE2(config-vrf)#rd 7.7.7.7:2`	Configure Route-Distinguisher value of `7.7.7.7:2`.
`PE2(config-vrf)#route-target both 2:2`	Configure import and export values for the `vrf2` as `2:2`.
`PE2(config-vrf)#exit`	Exit VRF mode and return to the configure mode.
`PE2(config)#commit`	Commit the transaction.

PE2: EVPN and VRF Mapping

The EVPN and VRF mapping configuration on PE2 establishes mappings between the EVPN identifier and VRF, facilitating efficient routing and connectivity in an EVPN network environment.

`PE2(config)#evpn mpls id 2 xconnect target-mpls-id 52`	Configure the EVPN-VPWS identifier with a source identifier of `2` and a target identifier of `52`.
`PE2(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Map VRF `vrf2` to the EVPN-VPWS identifier

PE2(config-evpn-mpls)#commit	Commit the transaction.
PE2(config-evpn-mpls)#exit	Exit the EVPN MPLS mode and return to the configure mode.

PE2: Access Port Configuration

The below access port configuration on PE2 is carried out to create a Layer 2 sub-interface within the port channel interface, set the load balancing, configure system MAC and the encapsulation with VLAN ID, map VPN-ID for efficient network access and connectivity.

PE2(config)#interface po1	Enter the port channel interface mode for po1
PE2(config-if)#load-interval 30	Set the load interval to 30.
PE2(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc	Configure the system-mac address 0000.aaaa.bbbc which plays a role in load balancing.
PE2(config-if)#interface po1.2 switchport	Create a Layer 2 sub-interface po1.2 within the port channel.
PE2(config-if)#encapsulation dot1q 2	Set encapsulation to dot1q with VLAN ID 2.
PE2(config-if)#access-if-evpn	Enter the access mode for EVPN MPLS ID configuration.
PE2(config-acc-if-evpn)#map vpn-id 2	Map VPN-ID 2.
PE2(config-acc-if-evpn)#exit	Exit the access mode and return to the interface mode.
PE2(config-if)#exit	Exit interface mode po1 and return to the configure mode.
PE2(config)#commit	Commit the transaction.

PE3: Loopback Interface

The configuration on PE3 for a loopback interface with IP address 8.8.8.8/32 secondary is set up to provide IP connectivity for the router.

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter the interface mode for the loopback interface lo.
PE3(config-if)#ip address 8.8.8.8/32 secondary	Configure a secondary IP address, 8.8.8.8/32, on the loopback interface.
PE3(config-if)#exit	Exit interface mode lo.
PE3(config)#commit	Commit the transaction.

PE3: Global LDP

The configuration on PE3 for the Global LDP router, specifying router ID and targeted peers, is done to set up Label Distribution Protocol (LDP) settings for MPLS.

PE3(config)#router ldp	Enter the Router LDP mode.
PE3(config-router)#router-id 8.8.8.8	Set the router ID for LDP to 7.7.7.7.
PE3(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer for LDP using IPv4 addresses.
PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#targeted-peer ipv4 7.7.7.7	Configure targeted peer for LDP using IPv4 addresses.

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PE3(config-router-targeted-peer)#exit-targeted-peer-mode	Exit router targeted-peer-mode.
PE3(config-router)#exit	Exit router LDP mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: Global EVPN MPLS Command

The configuration on PE3 for the Global EVPN MPLS, includes activating EVPN MPLS defining the global VTEP IP address, enabling hardware profile filtering for EVPN MPLS multihoming, and activating EVPN MPLS multihoming functionality, all of which are crucial for enabling EVPN MPLS features.

PE3(config)#evpn mpls enable	Activate the EVPN MPLS functionality on PE3, enabling it to participate in EVPN MPLS services.
PE3(config)#commit	Commit candidate configuration to be running configuration.
PE3(config)#evpn mpls vtep-ip-global 8.8.8.8	Configure the global VTEP IP address 8.8.8.8, associating it with the loopback IP.
PE3(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware-profile filter for EVPN MPLS multihoming.
PE3(config)#evpn mpls multihoming enable	Activate the EVPN MPLS multihoming functionality, allowing PE3 to support multihomed EVPN MPLS services.
PE3(config)#commit	Commit the transaction.

PE3: Interface Configuration Network Side

The below configuration is performed to set up network interfaces on PE3 and enable LDP for IPv4, ensuring proper routing and labeling functionality.

PE3(config)#interface xe5	Enter interface mode xe5.
PE3(config-if)#ip address 124.1.1.2/24	Configure an IP address, 124.1.1.2/24, on the interface xe5.
PE3(config-if)#enable-ldp ipv4	Enable LDP on the physical interface, facilitating the exchange of label information between devices in the network.
PE3(config-if)#label-switching	Enable label switching on the interface to enable MPLS-based packet forwarding.
PE3(config-if)#exit	Exit interface mode xe5.
PE3(config)#interface xe4	Enter the interface mode for xe4.
PE3(config-if)#channel-group 1 mode active	Attach LAG interface xe4.
PE3(config-if)#exit	Exit interface mode xe4 and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: OSPF Configuration

The below configuration is performed to set up OSPF on PE3, specifying the router ID and defining network interfaces.

PE3(config)#router ospf 1	Enter the router OSPF mode. Configure PE3 to run OSPF with process ID 1.
PE3(config-router)#ospf router-id 8.8.8.8	Set the OSPF router ID to 8.8.8.8, identifying PE3 within the OSPF network.

PE3(config-router)#network 8.8.8.8/32 area 0.0.0.0	Advertise loopback address in OSPF.
PE3(config-router)#network 124.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
PE3(config-router)#exit	Exit router OSPF mode and return to configure mode.
PE3(config)#commit	Commit the transaction.

PE3: BGP Configuration

The below BGP configuration on PE3 is established to enable BGP routing with ASN 1, set the BGP router ID, define iBGP neighbors, and enable the EVPN address family for efficient routing in an EVPN environment.

PE3(config)#router bgp 1	Enter the Router BGP mode, ASN: 1
PE3(config-router)#bgp router-id 8.8.8.8	Configure BGP router ID 8.8.8.8, identifying PE3 within the BGP network.
PE3(config-router)#neighbor 1.1.1.1 remote-as 1	Configure neighbor 1.1.1.1 as an iBGP neighbor with their remote AS number 1.
PE3(config-router)#neighbor 1.1.1.1 update-source lo	Configure neighbor 1.1.1.1 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#neighbor 7.7.7.7 remote-as 1	Configure neighbor 7.7.7.7 as an iBGP neighbor with their remote AS number 1.
PE3(config-router)#neighbor 7.7.7.7 update-source lo	Configure neighbor 7.7.7.7 as an iBGP neighbor, specifying the source of routing updates as the loopback interface.
PE3(config-router)#address-family l2vpn evpn	Enter into address family mode for L2VPN EVPN.
PE3(config-router-af)#neighbor 1.1.1.1 activate	Activate EVPN for iBGP neighbor 1.1.1.1 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#neighbor 7.7.7.7 activate	Activate EVPN for iBGP neighbor 7.7.7.7 within the address family mode, ensuring that EVPN address family is enabled for the neighbor.
PE3(config-router-af)#exit	Exit address family mode and return to the router BGP mode.
PE3(config-router)#commit	Commit the transaction.
PE3(config-router)#exit	Exit router BGP mode and return to the configure mode.

PE3: MAC VRF Configuration

The below MAC VRF configuration on PE3 is carried out to define and set up VRF named vrf2 with specific Route-Distinguisher (RD) and route-target values, ensuring segregated MAC address spaces for distinct network services.

PE3(config)#mac vrf vrf2	Enter VRF mode named vrf2.
PE3(config-vrf)#rd 8.8.8.8:2	Configure Route-Distinguisher value of 8.8.8.8:2.
PE3(config-vrf)#route-target both 2:2	Configure import and export values for the vrf2 as 2:2.
PE3(config-vrf)#exit	Exit VRF mode and return to the configure mode.
PE3(config)#commit	Commit the transaction.

PE3: EVPN and VRF Mapping

The EVPN and VRF mapping configuration on PE3 establishes mappings between the EVPN identifier and VRF, facilitating efficient routing and connectivity in an EVPN network environment.

`PE3(config)#evpn mpls id 2 xconnect target-mpls-id 52`	Configure the EVPN-VPWS identifier with a source identifier of `2` and a target identifier of `52`.
`PE3(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2`	Map VRF `vrf2` to the EVPN-VPWS identifier
`PE3(config-evpn-mpls)#commit`	Commit the transaction.
`PE3(config-evpn-mpls)#exit`	Exit the EVPN MPLS mode and return to the configure mode.

PE3: Access Port Configuration

The below access port configuration on PE3 is carried out to create a Layer 2 sub-interface within the port channel interface, set the load balancing, configure system MAC and the encapsulation with VLAN ID, map VPN-ID for efficient network access and connectivity.

`PE3(config)#interface po1`	Enter the port channel interface mode for `po1`
`PE3(config-if)#load-interval 30`	Set the load interval to `30`.
`PE3(config-if)#evpn multi-homed system-mac 0000.aaaa.bbbc`	Configure the system-mac address `0000.aaaa.bbbc` which plays a role in load balancing.
`PE3(config-if)#interface po1.2 switchport`	Create a Layer 2 sub-interface `po1.2` within the port channel.
`PE3(config-if)#encapsulation dot1q 2`	Set encapsulation to dot1q with VLAN ID `2`.
`PE3(config-if)#access-if-evpn`	Enter the access mode for EVPN MPLS ID configuration.
`PE3(config-acc-if-evpn)#map vpn-id 2`	Map VPN-ID `2`.
`PE3(config-acc-if-evpn)#exit`	Exit the access mode and return to the interface mode.
`PE3(config-if)#exit`	Exit interface mode `po1` and return to the configure mode.
`PE3(config)#commit`	Commit the transaction.

PE1: CFM

The following configuration enables CFM monitoring and maintenance for EVPN services on PE1.

`PE1(config)#hardware-profile filter cfm-domain-name-str enable`	Enable the CFM domain name as a character string profile for CFM filtering.
`PE1(config)#ethernet cfm domain-type character-string domain-name evpn1 level 7 mip-creation none`	Create a CFM domain for EVPN ELINE with a character string type and set MIP creation to `none`.
`PE1(config-ether-cfm)#service ma-type string ma-name evp1`	Define a maintenance association (MA) type with the string `evp1`.
`PE1(config-ether-cfm-ma)#evpn 52`	Configure the MA for EVPN ID `52`.
`PE1(config-ether-cfm-ma)#ethernet cfm mep up mpid 20 active true evpn 52`	Create an up-maintenance endpoint (MEP) for local EVPN ID `52`.
`PE1(config-ether-cfm-ma-mep)#cc multicast state enable`	Enable multicast continuity check (CC) state for the MEP.
`PE1(config-ether-cfm-ma-mep)#cc interval 100`	Set the CC interval to 100 milliseconds.

`PE1(config-ether-cfm-ma-mep)#exit-ether-ma-mep-mode`	Exit Ethernet MA MEP mode.
`PE1(config-ether-cfm-ma)#mep crosscheck mpid 10`	Configure cross-check to the remote MEP.
`PE1(config-ether-cfm-ma)#exit-ether-ma-mode`	Exit Ethernet MA mode.
`PE1(config-ether-cfm)#exit`	Exit Ethernet CFM mode and return to the configure mode.
`PE1(config)#commit`	Commit candidate configuration to be running configuration.

PE2/PE3: CFM

The following configuration enables CFM monitoring and maintenance for EVPN services on PE2 and PE3 devices.

Note: Apply the same set of configurations to the PE3 device.

`PE2(config)#hardware-profile filter cfm-domain-name-str enable`	Enable the CFM domain name as a character string profile for CFM filtering.
`PE2(config)#ethernet cfm domain-type character-string domain-name evpn1 level 7 mip-creation none`	Create a CFM domain for EVPN ELINE with a character string type and set MIP creation to `none`.
`PE2(config-ether-cfm)#service ma-type string ma-name evp1`	Define a maintenance association (MA) type with the string `evp1`.
`PE2(config-ether-cfm-ma)#evpn 2`	Configure the MA for EVPN ID `2`.
`PE2(config-ether-cfm-ma)#ethernet cfm mep up mpid 10 active true evpn 2`	Create an up-maintenance endpoint (MEP) for local EVPN ID `2`.
`PE2(config-ether-cfm-ma-mep)#cc multicast state enable`	Enable multicast continuity check (CC) state for the MEP.
`PE2(config-ether-cfm-ma-mep)#cc interval 100`	Set the CC interval to 100 milliseconds.
`PE2(config-ether-cfm-ma-mep)#exit-ether-ma-mep-mode`	Exit Ethernet MA MEP mode.
`PE2(config-ether-cfm-ma)#mep crosscheck mpid 20`	Configure cross-check to the remote MEP.
`PE2(config-ether-cfm-ma)#exit-ether-ma-mode`	Exit Ethernet MA mode.
`PE2(config-ether-cfm)#exit`	Exit Ethernet CFM mode and return to the configure mode.
`PE2(config)#commit`	Commit candidate configuration to be running configuration.

Validation

The following output displays the validation results for PE1, PE2, and PE3 in an EVPN setup, which includes EVPN xconnect status, Ethernet CFM errors, remote maintenance points, local maintenance points, and successful ping tests.

PE1: Display xConnect Status

```
PE1#show evpn mpls xconnect
EVPN Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up
```

```
Local                            Remote       Connection-Details
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP           MTU   Type   NW-Status
================================ ============
==================================================================================
52           ----          1500  2            xe33.2       00:00:00:aa:aa:bb:bb:00:00:00 7.7.7.7         1500  AC-NW  NW-SET
                                                                                         8.8.8.8         1500  ----   ----
```

PE1: Display Ethernet CFM errors

```
PE1#show ethernet cfm errors domain evpn1

Domain Name         Level     MEPID     Defects
-----------------------------------------------
evpn1               7         20        .....
```

PE1: Display Remote Maintenance Points

```
PE1#show ethernet cfm maintenance-points remote domain evpn1 ma-name evp1
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------

 20        10         7         Yes       False  00aa.bb00.0002 Configured
```

PE1: Display Local Maintenance Points

```
PE1#show ethernet cfm maintenance-points local mep domain evpn1 ma-name evp1
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address    Def Port  MD Name
---------------------------------------------------------------------------

20   Up  7   Enable  Installed  100 ms   3417.ebe4.af22 F   xe33.2 evpn1
```

PE1: Ping Test

```
PE1#ping ethernet mac 00aa.bb00.0002 unicast source 20 domain evpn1 ma evp1
 success rate is  100 (5/5)
```

PE2/PE3: Display xConnect Status

```
PE2#show evpn mpls xconnect
EVPN Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
==================================================================================
VPN-ID       EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP           MTU   Type   NW-Status
================================ ============
==================================================================================
2            ----          1500  52           po1.2        --- Single Homed Port ---     1.1.1.1         1500  AC-NW  NW-SET
```

PE2/PE3: Display Ethernet CFM errors

```
PE2#show ethernet cfm errors domain evpn1

Domain Name         Level     MEPID     Defects
-----------------------------------------------
evpn1               7         10        .....
```

PE2/PE3: Display Local Maintenance Points

```
PE2#show ethernet cfm maintenance-points local mep domain evpn1 ma-name evp1
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address    Def Port  MD Name
---------------------------------------------------------------------------

10   Up  7   Enable  Installed  100 ms   00aa.bb00.0002 F   po1.2 evpn1
```

PE2/PE3: Display Remote Maintenance Points

```
PE2#show ethernet cfm maintenance-points remote domain evpn1 ma-name evp1
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 10        20         7         Yes       False  3417.ebe4.af22 Configured
```

PE2/PE3: Ping and Traceroute Test

```
PE2#ping ethernet mac 3417.ebe4.af22 unicast source 10 domain evpn1 ma evp1
 success rate is  100 (5/5)
PE2#traceroute ethernet 3417.ebe4.af22 mepid 10 domain evpn1 ma evp1
 MP Mac         Hops  Relay-action          Ingress/Egress  Ingress/Egress action
3417.ebe4.af22   1     RlyHit                Ingress         IngOK
```

Implementation Examples

Here is a practical scenario and use case for CFM (802.1ag) implementation for ELINE MultiHoming in the context of a telecommunications service provider who offers Ethernet-based Virtual Private Network (EVPN) services to various enterprises.

Use Case: Ensuring Service Reliability and Quality

Scenario: Consider a company with several branch offices that rely heavily on its ELINE connections to ensure smooth communication and data exchange between offices. The company subscribes to an EVPN service provided by a telecommunications service provider.

Use Case Details

1. **MultiHoming Resilience:** The company's critical applications and services require high availability. MultiHoming ensures redundancy by connecting each branch office to the provider's network through multiple paths. This way, if one path fails due to network issues, the traffic can be rerouted through the alternative path without causing a disruption.

2. **Continuous Monitoring:** CFM implementation allows the service provider to continuously monitor the connectivity and performance of the ELINE connections between the branch offices. By sending CCMs, the provider can quickly identify any interruptions in connectivity.

3. **Swift Issue Detection and Resolution:** In case of a network disruption or fault, the service provider receives immediate alerts through CFM CCMs. This enables the provider's network operations team to pinpoint the issue's location and take prompt action to restore services, minimizing downtime for the company.

4. **Troubleshooting Efficiency:** The CFM Ping and Trace functions assist in troubleshooting network issues. If the company's IT team reports a performance issue or communication problem, use CFM diagnostic capabilities to trace the path of packets and identify bottlenecks or faulty segments.

In this use case, the CFM implementation for ELINE MultiHoming provides a robust solution for ensuring reliable and high-quality connectivity for the company's distributed offices. It enables proactive monitoring and rapid issue resolution, which are critical for maintaining the company's communication and operational efficiency.

Troubleshooting

Follow the troubleshooting steps below to resolve connectivity issues related to CFM EVPN-ID and crosscheck local and remote MEP ID matching.

1. **Check Local EVPN-ID:** Verify the EVPN-ID configured on the local device (Example: PE1) and ensure that it matches the intended EVPN-ID for the target service or connection.

2. **Verify Remote EVPN-ID:** Check the EVPN-ID configured on the remote device (Example: PE2) and confirm that it matches the EVPN-ID expected by the local device.
3. **Crosscheck MEP ID:** Examine the MEP ID configured on the local device (PE1) and ensure it matches the expected R-MEP ID on the remote device (PE2).
4. **Validate Remote MEP ID:** Verify the MEP ID configured on the remote device (PE2) and ensure it matches the R-MEP ID expected by the local device (PE1).
5. **Reconfigure If Needed:** If there are discrepancies between the local and remote EVPN-IDs or MEP IDs, reconfigure the devices to match.
6. **Test the Connection:** After ensuring that EVPN-IDs and MEP IDs match on both devices, test the connection to confirm it is established correctly.

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
CFM	Continuity Fault Management
CCM	Continuity Check Messages
EVPN	Ethernet Virtual Private Network
ELINE	Ethernet-LINE
MPLS	Multi-Protocol Label Switching
UP	User-to-Provider
MEP	Maintenance End Point
MH	MultiHoming
R-MEP	Remote Maintenance End Point
MAC	Media Access Control
AC	Access Circuit
TLV	Type-Length-Value
RDI	Remote Defect Indicator
LB	Loopback
LBM	Loopback Message
LTR	Looptrace Reply

Glossary

The following provides definitions for key terms used throughout this document.

Continuity Fault Management (CFM)	A protocol (802.1ag) that facilitates the monitoring of network connectivity by using Continuity Check Messages (CCM) to detect faults.
Continuity Check Messages (CCM)	Periodic messages are used in CFM to check the continuity of a network connection.
Ethernet Virtual Private Network (EVPN)	A technology that enables the extension of Layer 2 Ethernet networks over a Layer 3 infrastructure.
Multi-Protocol Label Switching (MPLS)	In telecommunications networks, a routing technique is employed to guide data from one node to the next using concise path labels rather than relying on lengthy network addresses.
User-to-Provider (UP)	Refers to the connection between the user's and service provider's networks.
Maintenance End Point (MEP)	A point in a network where maintenance operations are initiated or terminated.
MultiHoming (MH)	A networking architecture that allows a device to be connected to multiple network paths or points of attachment.
Remote Maintenance End Point (R-MEP)	A maintenance end point located remotely from the originating point.
Media Access Control (MAC)	A unique identifier assigned to a network interface card.
Attachment Circuit (AC)	A circuit that connects a customer's equipment to a provider's network.
Type-Length-Value (TLV)	A format used to encapsulate data in a variety of protocols.
Remote Defect Indication (RDI)	A signal used to indicate a fault condition in a network link.
Loopback Message (LBM)	A message used in loopback testing to check connectivity.

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CHAPTER 11 Inter-AS VPN Configuration Overview

MPLS VPN architecture typically runs within an AS. Routes of any VPN can be flooded within the AS, but not to other ASs. To implement the exchange of VPN routes between different ASs, the inter-AS MPLS VPN model is used. The inter-AS MPLS VPN model is an extension to MPLS VPN framework. Route prefixes and labels can be advertised over links between different carrier networks through the inter-AS MPLS model.

The MPLS VPN solution serves an increasing number of users across many applications. A site at one geographical location often needs to connect to an ISP network at another geographical location. In this situation, for example, inter-AS issues may arise for operators who manage different metropolitan area networks (MANs) or backbone networks that span different autonomous systems (AS).

Types of Inter-AS VPN

1. Inter-AS VPN Option A: Autonomous system boundary routers (ASBRs) manage VPN routes for in-ter-AS VPNs through dedicated interfaces.

2. Inter-AS VPN Option B: ASBRs advertise labeled VPN-IPv4 routes to each other through MP-EBGP.

3. Inter-AS VPN Option C: PE devices advertise labeled VPN-IPv4 routes to each other through Mul-ti-hop MP-EBGP.

CHAPTER 12 Inter-AS VPN Option-A Configuration

This chapter explain about Inter-AS VPN Option-A. Option A is the simplest of the options to inter-connect the ASBRs Option A has the following characteristics:

- Each customer VRF requires either a physical interface or more likely a subinterface.
- Each ASBR thinks the other is a CE.
- One logical interface per VPN.
- Link may use any supported PE-CE protocol.
- Packets are sent unlabelled between the ASBRs.
- The most secure and easy option to provision.
- Does not scale well to a large number of VPNs.

Topology

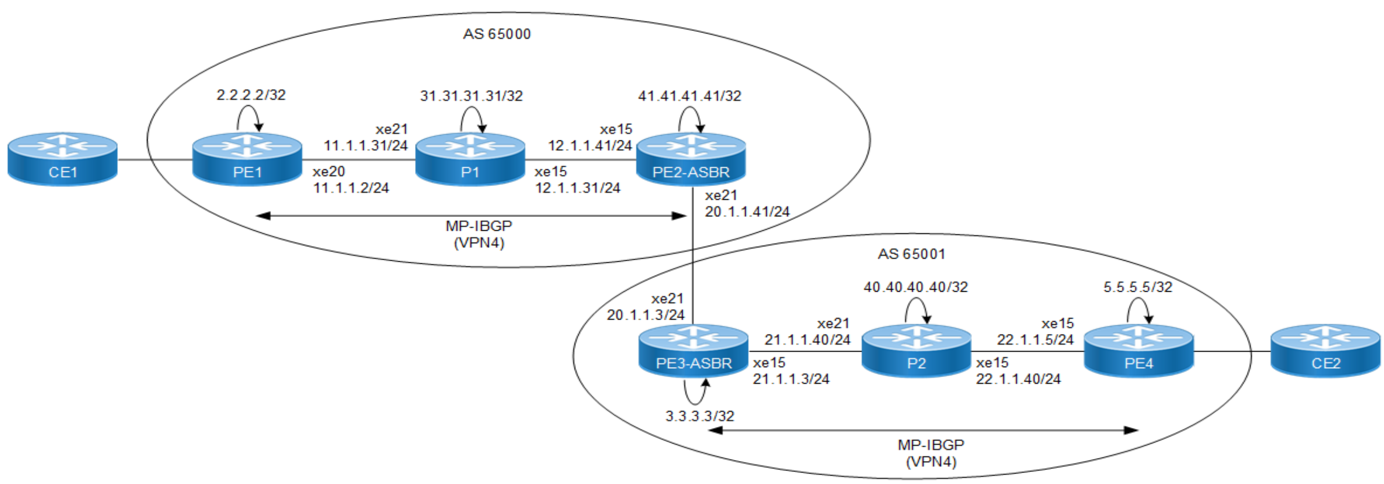


Figure 12-3: InterAS-VPN Option-A

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 2.2.2.2/32 secondary`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#ip vrf vrf1`	Create a new VRF named vrf1.
`(config-vrf)#rd 1:1`	Assign the route distinguisher (RD) value as 1:1.
`(config-vrf)#route-target both 1:1`	Import routes between route target (RT) ext-communities.
`(config-vrf)#exit`	Exit interface mode.
`(config)#interface xe22`	Enter interface mode.
`(config-if)#ip vrf forwarding vrf1`	Bind the interface connected to the CE router with VRF vrf1
`(config-if)#ip address 10.1.1.2/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode

(config)#interface xe20	Enter interface mode
(config-if)#ip address 11.1.1.2/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router id same as loopback ip address.
(config-router)#network 2.2.2.2/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 11.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 2.2.2.2	Configure the router ID same as loopback IP address.
(config-router)#transport-address ipv4 2.2.2.2	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe20	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65000	Enter BGP router mode.
(config-router)#bgp router-id 2.2.2.2	Configure BGP router-id.
(config-router)#neighbor 41.41.41.41 remote-as 65000	Configure PE2-ASBR1 as an iBGP peer.
(config-router)#neighbor 41.41.41.41 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 41.41.41.41 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#exit	Exit OSPF router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

P1 Configuration

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 31.31.31.31/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.

(config)#interface xe21	Enter interface mode.
(config-if)#ip address 11.1.1.31/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 12.1.1.31/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 31.31.31.31	Configure OSPF router ID same as loopback IP address.
(config-router)#network 31.31.31.31/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 11.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 12.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 31.31.31.31	Configure the router id same as loopback ip address.
(config-router)#transport-address ipv4 31.31.31.31	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-router)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE2-ASBR1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 41.41.41.41/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit interface mode.

(config)#interface xe21	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
(config-if)#ip address 20.1.1.41/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 12.1.1.41/24	Assign the IPv4 address.
(config-if)#	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 41.41.41.41	Configure OSPF router ID same as loopback IP address.
(config-router)#network 41.41.41.41/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 12.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#transport-address ipv4 41.41.41.41	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-router)#exit	Exit interface mode.
(config)#router bgp 65000	Enter BGP router mode.
(config-router)#bgp router-id 41.41.41.41	Configure BGP router-id.
(config-router)#neighbor 2.2.2.2 remote-as 65000	Configure PE1 as an iBGP peer.
(config-router)#neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 2.2.2.2 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#neighbor 20.1.1.3 remote-as 65001	Configure eBGP neighbor.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE3-ASBR2

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 3.3.3.3/32 secondary`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#ip vrf vrf1`	Create a new VRF named vrf1.
`(config-vrf)#rd 1:1`	Assign the route distinguisher (RD) value as 1:1.
`(config-vrf)#route-target both 1:1`	Import routes between route target (RT) ext-communities.
`(config-vrf)#exit`	Exit interface mode.
`(config)#interface xe21`	Enter interface mode.
`(config-if)#ip vrf forwarding vrf1`	Bind the interface connected to the CE router with VRF vrf1.
`(config-if)#ip address 20.1.1.3/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#ip address 21.1.1.3/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 1`	Enter router OSPF mode.
`(config-router)#ospf router-id 3.3.3.3`	Configure OSPF router id same as loopback ip address.
`(config-router)#network 3.3.3.3/32 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#network 21.1.1.0/24 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#exit`	Exit OSPF router mode.
`(config)#router ldp`	Enter router LDP mode.
`(config-router)#router-id 3.3.3.3`	Configure the router ID same as loopback IP address.
`(config-router)#transport-address ipv4 3.3.3.3`	Configure LDP transport address same as loopback address.
`(config-router)#exit`	Exit LDP mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-ldp ipv4`	Enable LDP in interface.
`(config-router)#exit`	Exit interface mode.
`(config)#router rsvp`	Enter router RSVP mode.
`(config-router)#rsvp-trunk lsp1`	Create an RSVP trunk lsp1 and enter the Trunk mode.
`(config-trunk)#to 5.5.5.5`	Specify the IPv4 egress (destination point-PE4 loopback address) for the LSP.
`(config-trunk)#exit`	Exit interface mode.
`(config)#router bgp 65001`	Enter BGP router mode.
`(config-router)#bgp router-id 3.3.3.3`	Configure BGP router-id.
`(config-router)#neighbor 5.5.5.5 remote-as 65001`	Configure PE4 as an iBGP peer.

(config-router)#neighbor 5.5.5.5 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 5.5.5.5 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#neighbor 20.1.1.41 remote-as 65000	Configure eBGP neighbor.
(config-router-af)#neighbor 20.1.1.41 activate	Activate the eBGP neighbor under address family.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

P2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 40.40.40.40/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe21	Enter interface mode.
(config-if)#ip address 21.1.1.40/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 22.1.1.40/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 40.40.40.40	Configure OSPF router ID same as loopback IP address.
(config-router)#network 40.40.40.40/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 21.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 22.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 40.40.40.40	Configure the router ID same as loopback IP address.
(config-router)#transport-address ipv4 40.40.40.40	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.

(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE4

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create a new VRF named vrf1.
(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
(config-vrf)#route-target both 1:1	Import routes between route target (RT) ext-communities.
(config-vrf)#exit	Exit VRF mode.
(config)#interface xe22	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
(config-if)#ip address 30.1.1.5/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 22.1.1.5/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 5.5.5.5	Configure OSPF router ID same as loopback IP address.
config-router)#network 5.5.5.5/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 22.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit router OSPF mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 5.5.5.5	Configure the router ID same as loopback IP address.
(config-router)#transport-address ipv4 5.5.5.5	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.

(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65001	Enter BGP router mode.
(config-router)#bgp router-id 5.5.5.5	Configure BGP router-id.
(config-router)#neighbor 3.3.3.3 remote-as 65001	Configure PE2-ASBR1 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 3.3.3.3 activate	Activate neighbor.
(config-router-af)#exit	Exit VPNv4 Address Family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter IPv4 VRF Address Family mode.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

Validation

PE1

```
#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
C    *>  10.1.1.0/24 is directly connected, xe22, 01:05:28
B    *>  20.1.1.0/24 [200/0] via 41.41.41.41, 00:01:18
B    *>  30.1.1.0/24 [200/0] via 41.41.41.41, 00:00:24
C    *>  127.0.0.0/8 is directly connected, lo.vrf1, 01:06:20

Gateway of last resort is not set
#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
```

```
*> l 10.1.1.0/24      0.0.0.0             0         100           32768    ?
*>i  20.1.1.0/24      41.41.41.41         0         100           0        ?
*>i  30.1.1.0/24      41.41.41.41         0         100           0
65001 ?
 Announced routes count = 1
 Accepted routes count = 2
Route Distinguisher: 1:1
*>i  20.1.1.0/24      41.41.41.41         0         100           0        ?
*>i  30.1.1.0/24      41.41.41.41         0         100           0
65001 ?
 Announced routes count = 0
 Accepted routes count = 2
```

PE2-ASBR1

```
#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
C    *>  20.1.1.0/24 is directly connected, xe22, 01:05:28
B    *>  10.1.1.0/24 [200/0] via 2.2.2.2, 00:01:18
B    *>  30.1.1.0/24 [20/0] via 20.1.1.3, xe2, 00:54:13
C    *>  127.0.0.0/8 is directly connected, lo.vrf1, 01:06:20

Gateway of last resort is not set

#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*>i  10.1.1.0/24      2.2.2.2             0         100           0        ?
*> l 20.1.1.0/24      0.0.0.0             0         100           32768    ?
*    20.1.1.0/24      20.1.1.3            0         100           0
65001 ?
*> l 30.1.1.0/24      20.1.1.3            0         100           0
65001 ?
 Announced routes count = 3
 Accepted routes count = 1
Route Distinguisher: 1:1
*>i  10.1.1.0/24      2.2.2.2             0         100           0        ?
 Announced routes count = 0
 Accepted routes count = 1
```

PE3-ASBR2

```
#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
```

```
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
B    *>  10.1.1.0/24 [20/0] via 20.1.1.41, xe22, 00:55:54
C    *>  20.1.1.0/24 is directly connected, xe22, 01:05:28
B    *>  30.1.1.0/24 [200/0] via 5.5.5.5, 00:01:18
C    *>  127.0.0.0/8 is directly connected, lo.vrf1, 01:06:20

Gateway of last resort is not set
#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*> l 10.1.1.0/24      20.1.1.41           0         100           0
65000 ?
*> l 20.1.1.0/24      0.0.0.0             0         100           32768    ?
*    20.1.1.0/24      20.1.1.41           0         100           0
65000 ?
*>i  30.1.1.0/24      5.5.5.5             0         100           0        ?
 Announced routes count = 3
 Accepted routes count = 1
Route Distinguisher: 1:1
*>i  30.1.1.0/24      5.5.5.5             0         100           0        ?
 Announced routes count = 0
 Accepted routes count = 1
```

PE4

```
#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
B    *>  10.1.1.0/24 [200/0] via 3.3.3.3, 00:00:08
B    *>  20.1.1.0/24 [200/0] via 3.3.3.3, 00:02:45
C    *>  30.1.1.0/24 is directly connected, xe18, 01:02:20
C    *>  127.0.0.0/8 is directly connected, lo.vrf1, 01:05:36

Gateway of last resort is not set

#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
```

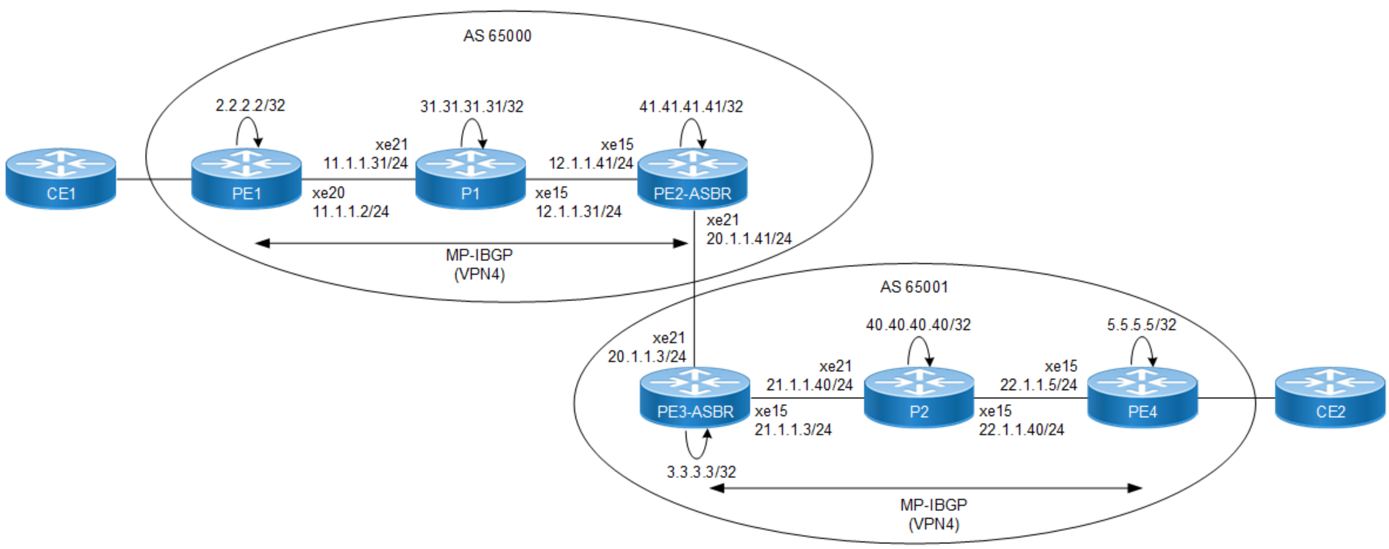
```
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*>i  10.1.1.0/24      3.3.3.3              0        100          0
65000 ?
*>i  20.1.1.0/24      3.3.3.3              0        100          0        ?
*> l 30.1.1.0/24      0.0.0.0              0        100          32768    ?
 Announced routes count = 1
 Accepted routes count = 2
Route Distinguisher: 1:1
*>i  10.1.1.0/24      3.3.3.3              0        100          0
65000 ?
*>i  20.1.1.0/24      3.3.3.3              0        100          0        ?
 Announced routes count = 0
 Accepted routes count = 2
```

CHAPTER 13 Inter-AS VPN Option-B Configuration

- Inter-AS Option B is a more scalable solution compared to Option A. It does not require any VRFs on the ASBRs, it uses VPNv4 eBGP to exchange VPNv4 updates.
- Single interface to connect the ASBRs.
- Packets are sent labelled between the ASBRs.
- No need for VRFs on the ASBR.
- ASBRs must be directly connected.
- Scales better than Option A.

Note: ASBR BGP label allocation mode uses per-prefix label allocation, and per-VRF label allocation cannot be achieved in ASBRs (VPNv4 and VPNv6).

Topology



PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 2.2.2.2/32 secondary`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#ip vrf vrf1`	Create a new VRF named vrf1.
`(config-vrf)#rd 1:1`	Assign the route distinguisher (RD) value as 1:1.
`(config-vrf)#route-target both 1:1`	Import routes between route target (RT) ext-communities.
`(config-vrf)#exit`	Exit VRF mode.
`(config)#interface xe22`	Enter interface mode.
`(config-if)#ip vrf forwarding vrf1`	Bind the interface connected to the CE router with VRF vrf1.
`(config-if)#ip address 10.1.1.2/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.

`(config)#interface xe20`	Enter interface mode.
`(config-if)#ip address 11.1.1.2/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Enter router OSPF mode.
`(config-router)#ospf router-id 2.2.2.2`	Configure OSPF router id same as loopback ip address.
`(config-router)#network 2.2.2.2/32 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#network 11.1.1.0/24 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#exit`	Exit OSPF router mode.
`(config)#router ldp`	Enter router LDP mode.
`(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2
`(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address
`(config-router)#targeted-peer ipv4 41.41.41.41`	Configure targeted peer.
`(config-router)#targeted-peer ipv4 3.3.3.3`	Configure targeted peer.
`(config-router-targeted-peer)#targeted-peer ipv4 5.5.5.5`	Configure targeted peer.
`(config-router-targeted-peer)#targeted-peer ipv4 41.41.41.41`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode.
`(config-router)#exit`	Exit router mode
`(config)#interface xe20`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-ldp ipv4`	Enable LDP in interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 65000`	Enter BGP router mode.
`(config-router)#bgp router-id 2.2.2.2`	Configure BGP router-id.
`(config-router)#neighbor 41.41.41.41 remote-as 65000`	Configure PE2-ASBR1 as an iBGP peer.
`(config-router)#neighbor 41.41.41.41 update-source lo`	Update the source as loopback for iBGP peering with the remote PE2 router.
`(config-router)#address-family vpnv4`	Enter VPNv4 address family mode.
`(config-router-af)#neighbor 41.41.41.41 activate`	Activate the PE neighbor so that it can accept VPN IPv4 routes.
`(config-router-af)#exit`	Exit VPNv4 address family mode.
`(config-router)#address-family ipv4 vrf vrf1`	Enter the IPv4 address family for VRF vrf1.
`(config-router-af)#redistribute connected`	Redistribute connected route.
`(config-router-af)#commit`	Commit the transaction.
`(config-router-af)#exit-address-family`	Exit address family mode.
`(config-router)#exit`	Exit the router mode.

(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 31.31.31.31/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe21	Enter interface mode.
(config-if)#ip address 11.1.1.31/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 12.1.1.31/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 31.31.31.31	Configure OSPF router id same as loopback ip address.
(config-router)#network 31.31.31.31/32 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 11.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#network 12.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router LDP mode.
(config-router)#router-id 31.31.31.31	Set the router ID to IP address 31.31.31.31
(config-router)#transport-address ipv4 31.31.31.31	Configure LDP transport address same as loopback address.
(config-router)#exit	Exit LDP mode.
(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

PE2-ASBR

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 41.41.41.41/32 secondary`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 41.41.41.41`	Set the router ID to IP address 41.41.41.41
`(config-router)#transport-address ipv4 41.41.41.41`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 2.2.2.2`	Configure targeted peer.
`(config-router-targeted-peer)#targeted-peer ipv4 3.3.3.3`	Configure targeted peer.
`(config-router-targeted-peer)#targeted-peer ipv4 5.5.5.5`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#ip address 12.1.1.41/24`	Assign ipv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Enter router OSPF mode.
`(config-router)#ospf router-id 41.41.41.41`	Configure OSPF router id same as loopback ip address.
`(config-router)#network 41.41.41.41/32 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#network 12.1.1.0/24 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#exit`	Exit OSPF router mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-ldp ipv4`	Enable LDP in interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe21`	Enter interface mode.
`(config-if)#ip address 20.1.1.41/24`	Assign the IPv4 address.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 65000`	Enter BGP router mode.
`(config-router)#bgp router-id 41.41.41.41`	Configure BGP router-id.
`(config-router)#no bgp inbound-route-filter`	Disable inbound route filter.
`(config-router)#neighbor 2.2.2.2 remote-as 65000`	Configure PE1 as an iBGP peer.

(config-router)#neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#neighbor 20.1.1.3 remote-as 65001	Configure eBGP neighbor with ASBR2.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 2.2.2.2 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#neighbor 2.2.2.2 next-hop-self	Configure this to make the router the next hop for a BGP neighbor.
(config-router-af)#neighbor 20.1.1.3 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#neighbor 20.1.1.3 allow-ebgp-vpn	Configure this to allow exchange of VPN updates between eBGP peers.
(config-router-af)#neighbor 20.1.1.3 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#commit	Commit candidate configuration to the running configuration.

PE3-ASBR

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 2.2.2.2	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 41.41.41.41	Configure targeted peer.
(config-router-targeted-peer)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe21	Enter interface mode.
(config-if)#ip address 20.1.1.3/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 21.1.1.3/24	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Enter router OSPF mode.
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router id same as loopback ip address.
(config-router)#network 3.3.3.3/32 area 0	Define the network on which OSPF runs and associate area id.

(config-router)#network 21.1.1.0/24 area 0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit OSPF router mode.
(config)#router ldp	Enter router ldp mode.
(config-router)#transport-address ipv4 3.3.3.3	Configure LDP transport address same as loopback address
(config-router)#exit	Exit LDP mode.
(config)#interface xe15	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#enable-ldp ipv4	Enable LDP in interface.
(config-router)#exit	Exit LDP mode.
(config)#interface xe21	Enter interface mode.
(config-if)#label-switching	Enable label switching in interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 65001	Enter BGP router mode.
(config-router)#bgp router-id 3.3.3.3	Configure BGP router-id.
(config-router)#no bgp inbound-route-filter	Disable inbound route filter.
(config-router)#neighbor 5.5.5.5 remote-as 65001	Configure PE4 as an iBGP peer.
(config-router)#neighbor 5.5.5.5 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#neighbor 20.1.1.41 remote-as 65000	Configure eBGP neighbor with PE4.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 5.5.5.5 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#neighbor 5.5.5.5 next-hop-self	Configure this to make the router the next hop for a BGP neighbor.
(config-router-af)#neighbor 20.1.1.41 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#neighbor 20.1.1.41 allow-ebgp-vpn	Configure this to allow exchange of vpn updates between eBGP peers.
(config-router-af)#neighbor 20.1.1.41 activate	Activate the ASBR eBGP neighbor.
(config-router-af)#commit	Commit candidate configuration to be running configuration.

P2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 40.40.40.40/32 secondary	Assign the IPv4 address.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 40.40.40.40	Set the router ID to IP address 40.40.40.40

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`(config-router)#transport-address ipv4 40.40.40.40`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 40.40.40.40`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode
`(config)#interface xe21`	Enter interface mode.
`(config-if)#ip address 21.1.1.40/24`	Assign the IPv4 address.
`(config-if)#exit (config-router)#targeted-peer ipv4 40.40.40.40`	Exit interface mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#ip address 22.1.1.40/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Enter router OSPF mode.
`(config-router)#ospf router-id 40.40.40.40`	Configure OSPF router id same as loopback ip address.
`(config-router)#network 40.40.40.40/32 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#network 21.1.1.0/24 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#network 22.1.1.0/24 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#exit`	Exit OSPF router mode.
`(config)#router ldp`	Enter router LDP mode.
`(config-router)#transport-address ipv4 40.40.40.40`	Configure LDP transport address same as loopback address.
`(config-router)#exit`	Exit LDP mode.
`(config)#interface xe21`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-ldp ipv4`	Enable ldp in interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-ldp ipv4`	Enable LDP in interface.
`(config-if)#commit`	Commit the transaction.
`(config-if)#exit`	Exit interface mode.
`(config)#commit`	Commit candidate configuration to be running configuration.
`(config)#exit`	Exit the config mode.

PE4

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 5.5.5.5/32 secondary`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 5.5.5.5`	Set the router ID to IP address 5.5.5.5
`(config-router)#transport-address ipv4 5.5.5.5`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 5.5.5.5`	Configure targeted peer.
`(config-router-targeted-peer)# targeted-peer ipv4 2.2.2.2`	Configure targeted peer.
`(config-router-targeted-peer)# targeted-peer ipv4 41.41.41.41`	Configure targeted peer.
`(config-router-targeted-peer)# targeted-peer ipv4 3.3.3.3`	Configure targeted peer.
`(config-router)#exit`	Exit router mode
`(config)#ip vrf vrf1`	Create a new VRF named vrf1.
`(config-vrf)#rd 1:1`	Assign the route distinguisher (RD) value as 1:1.
`(config-vrf)#route-target both 1:1`	Import routes between route target (RT) ext-communities.
`(config-vrf)#exit`	Exit VRF mode.
`(config)#interface xe22`	Enter interface mode.
`(config-if)#ip vrf forwarding vrf1`	Bind the interface connected to the CE router with VRF vrf1.
`(config-if)#ip address 30.1.1.5/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#ip address 22.1.1.5/24`	Assign the IPv4 address.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Enter router OSPF mode.
`(config-router)#ospf router-id 5.5.5.5`	Configure OSPF router id same as loopback ip address.
`(config-router)#network 5.5.5.5/32 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#network 22.1.1.0/24 area 0`	Define the network on which OSPF runs and associate area id.
`(config-router)#exit`	Exit OSPF router mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-ldp ipv4`	Enable LDP in interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 65001`	Enter BGP router mode.

(config-router)#bgp router-id 5.5.5.5	Configure BGP router-id.
(config-router)#neighbor 3.3.3.3 remote-as 65001	Configure PE2-ASBR1 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family vpnv4	Enter VPNv4 address family mode.
(config-router-af)#neighbor 3.3.3.3 activate	Activate the PE neighbor so that it can accept VPN IPv4 routes.
(config-router-af)#exit	Exit VPNv4 address family mode.
(config-router)#address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
(config-router-af)#redistribute connected	Redistribute connected route.
(config-router-af)#commit	Commit the transaction.
(config-router-af)#exit-address-family	Exit address family mode.
(config-router)#exit	Exit the router mode.
(config)#commit	Commit candidate configuration to be running configuration.
(config)#exit	Exit the config mode.

Validation

PE1

```
PE1#sh ldp session
Peer IP Address    IF Name   My Role   State       KeepAlive   UpTime
31.31.31.31         xe20     Passive    OPERATIONAL 30         00:49:02

#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
C    *>  10.1.1.0/24 is directly connected, xe22, 03:49:26
B    *>  30.1.1.0/24 [200/0] via 41.41.41.41, 00:00:41
C    *>  127.0.0.0/8 is directly connected, lo.vrf1, 03:50:18

PE1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
```

```
*> l 10.1.1.0/24      0.0.0.0              0         100           32768    ?
*>i  30.1.1.0/24      41.41.41.41          0         100           0
65001 ?
 Announced routes count = 1
 Accepted routes count = 1
Route Distinguisher: 1:1
*>i  30.1.1.0/24      41.41.41.41          0         100           0
65001 ?
 Announced routes count = 0
 Accepted routes count = 1
```

PE2-ASBR1

```
PE2-ASBR2#show ldp session
Peer IP Address  IF Name      My Role    State     KeepAlive UpTime
31.31.31.31      xe47         Active   OPERATIONAL  30       00:16:22
3.3.3.3          xe45         Active   OPERATIONAL  30       00:14:54



#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1
*>il 10.1.1.0/24      2.2.2.2              0         100           0        ?
*> l 30.1.1.0/24      20.1.1.3             0         100           0
65001 ?
 Announced routes count = 0
 Accepted routes count = 2

#show ip bgp vpnv4 all summary
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 4
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
2.2.2.2                  4 65000  168        171       4      0      0
00:29:03              1
20.1.1.3                 4 65001  111        119       4      0      0
00:42:51              1

Total number of neighbors 2

Total number of Established sessions 2
```

PE3-ASBR2

```
PE3-ASBR2#sh ldp session
Peer IP Address   IF Name   My Role    State      KeepAlive   UpTime
41.41.41.41        xe45     Passive    OPERATIONAL 30         00:15:47
40.40.40.40        xe6      Passive    OPERATIONAL 30         00:24:32
```

```
#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1
*> l 10.1.1.0/24      20.1.1.41            0         100           0
65000 ?
*>il 30.1.1.0/24      5.5.5.5              0         100           0        ?
 Announced routes count = 0
 Accepted routes count = 2

#show ip bgp vpnv4 all summary
BGP router identifier 3.3.3.3, local AS number 65001
BGP table version is 4
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
5.5.5.5                  4 65001   41         45       4      0      0
00:15:59               1
20.1.1.41                4 65000  115        118       4      0      0
00:43:58               1

Total number of neighbors 2

Total number of Established sessions 2
```

PE4

```
#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*>i  10.1.1.0/24      3.3.3.3              0         100           0
65000 ?
*> l 30.1.1.0/24      0.0.0.0              0         100           32768    ?
 Announced routes count = 1
 Accepted routes count = 1
Route Distinguisher: 1:1
*>i  10.1.1.0/24      3.3.3.3              0         100           0
65000 ?
 Announced routes count = 0
 Accepted routes count = 1

#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
```

```
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
B    *>  10.1.1.0/24 [200/0] via 3.3.3.3, 00:00:48
C    *>  30.1.1.0/24 is directly connected, xe22, 03:46:38
C    *>  127.0.0.0/8 is directly connected, lo.vrf1, 03:49:54

Gateway of last resort is not set

PE4#sh ldp session

Peer IP Address   IF Name    My Role   State       KeepAlive  UpTime
40.40.40.40        xe5       Passive   OPERATIONAL 30         00:26:30

P#sh ldp session
Peer IP Address     IF Name     My Role    State      KeepAlive   UpTime
2.2.2.2              xe7        Active    OPERATIONAL  30         00:31:27
41.41.41.41          xe1        Passive   OPERATIONAL  30         00:15:12


P#
P2#sh ldp session
Peer IP Address     IF Name      My Role   State      KeepAlive    UpTime
3.3.3.3             xe6          Active   OPERATIONAL  30         00:24:58
5.5.5.5             xe5          Active   OPERATIONAL  30         00:24:15
```

CHAPTER 14 Inter-AS VPN Option-C Configuration

This is an option which enables BGP VPNv4 routes exchange between the two or more Provider Edge routers residing in different AS'es. There is no VPNv4 route exchange between the ASBRs and hence the ASBRs are completely transparent of the VPNs provisioned on the connecting AS'es. This option is more scalable than the previous two options because it removes the restriction of installing VPNv4 LFIB entries on the ASBRs hence reducing the resource requirements on them. ASBRs are only required to forward data based on the transport LSPs configured.

Pre-requisites to successfully configure this option.

- There should be end to end transport LSP between the two PE's residing in different AS'es.
- Could use BGP Labeled-unicast to exchange labels for the two PE's residing in different AS'es.
- This option can utilize RR's to exchange VPNv4 routes between the two AS'es and hence should have capability to keep the next-hops unchanged when reflecting routes from iBGP to eBGP
- LDP/RSVP/SR can be used as a transport within the AS.

There are multiple ways in which this option can be configured.

- Inter-AS Option-C with VPNv4 Routes exchange between the two RRs in different AS'es
- Inter-AS Option-C with VPNv4 Routes exchange between two PE's in different AS.
- Inter-AS Option-C with VPNv4 Routes exchange between PE of one AS and RR of another AS.

This section explains the configuration for the first two points.

Inter-AS Option-C with RR

This sub-option enables VPNv4 routes exchange between the Route-Reflectors of different AS'es and thus requires

1. Remote PE loopback addresses to be known in the AS - This is accomplished using BGP-LU and is advertised inside the AS using the Route-reflector and outside the AS using the eBGP Peering between the ASBRs.
2. MP-eBGP peering between the two RRs of different AS'es in order to exchange VPNv4 routes.
3. To be able to have an eBGP session between RR's, Remote Route-reflector Loopback addresses are required to be known in the local AS and vice-versa. This is accomplished using the mutual redistribution between OSPF and bgp on the two ASBRs. The redistribution is controlled using the route-maps and only permits the
    1. Local Route-reflectors Loopback address to be redistributed from local OSPF to BGP.
    2. Remote Route-reflectors Loopback address to be redistributed from bgp to local OSPF.
4. Next-hop attribute should not be changed when RR reflects the VPNv4 route from iBGP peering to the remote RR over an eBGP peering. This is accomplished using the configuration "attribute-unchanged next-hop" for the eBGP neighbor.
5. Next-hop attribute should be changed when ASBR advertises the remote PE's Loopback address as LU route to the RR. This is accomplished using the configuration "next-hop self" for the iBGP RR neighbor

(1) and (5) enables an end to end LSP between the two PE's which needs to run the L3VPN service and (2), (3) and (4) enables the RR's to form BGP neighborship with each other and successfully exchange the VPNv4 Routes.

Topology

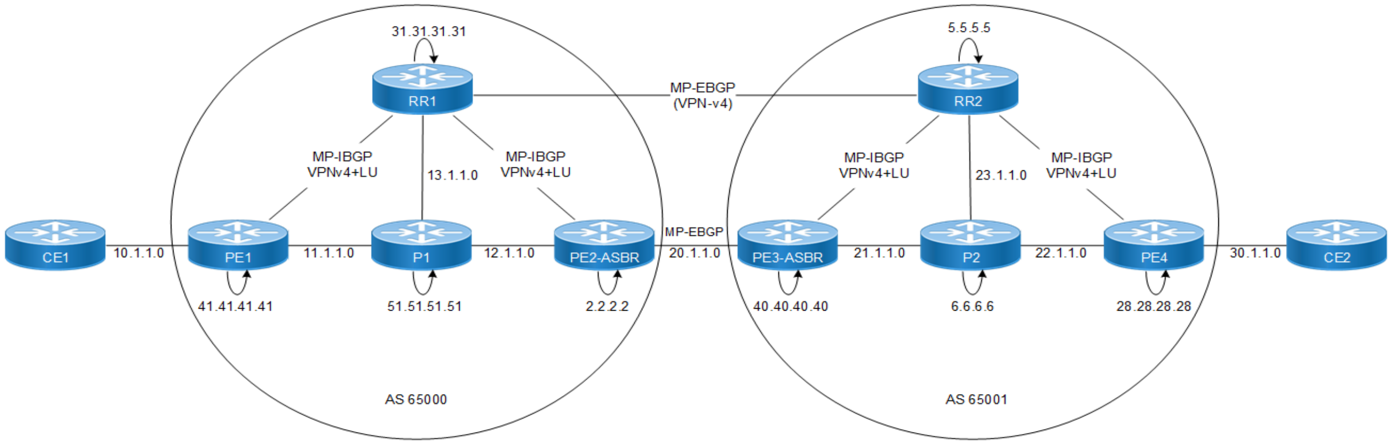

Figure 14-4: InterAS-VPN Option-C with RR

PE1

`PE1(#configure terminal`	Enter configure mode.
`PE1(config-router)#interface lo`	Enter interface mode.
`PE1(config-if)# ip address 41.41.41.41/32 secondary`	Assign the IPv4 address.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config)#ip vrf vrf1`	Create a new VRF named vrf1.
`PE1(config-vrf)# rd 1:1`	Assign the route distinguisher (RD) value as 1:1.
`PE1(config-vrf)# route-target both 1:1`	Configure import and export route-target values
`PE1(config-vrf)#exit`	Exit VRF mode.
`PE1(config-if)#interface xe23`	Enter interface mode.
`PE1(config-if)# ip vrf forwarding vrf1`	Bind the interface connected to the CE router with VRF vrf1.
`PE1(config-if)# ip address 10.1.1.2/24`	Assign the IPv4 address.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config-if)#interface xe15`	Enter interface mode.
`PE1(config-if)# ip address 11.1.1.2/24`	Assign the IPv4 address.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config-if)#router ospf 1`	Enter router OSPF mode.
`PE1(config-router)# ospf router-id 41.41.41.41`	Configure OSPF router id same as loopback ip address.
`PE1(config-router)# network 11.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`PE1(config-router)# network 41.41.41.41/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`PE1(config)#router ldp`	Enter router LDP mode.
`PE1(config-router)#router-id 41.41.41.41`	Set the router ID to IP address 41.41.41.41
`PE1(config-router)#transport-address ipv4 41.41.41.41`	Configure LDP transport address same as loopback address.

`PE1(config-router)#exit`	Exit LDP mode.
`PE1(config-if)#interface xe15`	Enter interface mode.
`PE1(config-if)# label-switching`	Enable label switching in interface.
`PE1(config-if)# enable-ldp ipv4`	Enable LDP in interface.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config-router)#router bgp 65000`	Enter BGP router mode.
`PE1(config-router)# bgp router-id 41.41.41.41`	Configure BGP router-id.
`PE1(config-router)# no bgp default ipv4-unicast`	Configure BGP peer to have no ipv4 unicast capability exchange by default.
`PE1(config-router)# neighbor 31.31.31.31 remote-as 65000`	Configure neighbor with remote AS.
`PE1(config-router)# neighbor 31.31.31.31 update-source lo`	Update the loopback as the source of BGP session.
`PE1(config-router)# allocate-label all`	Allocate the label for all advertised networks.
`PE1(config-router)# address-family ipv4 labeled-unicast`	Enter the IPv4 labeled-unicast address family
`PE1(config-router-af)# neighbor 31.31.31.31 activate`	Activate the neighbor under the address-family.
`PE1(config-router-af)# exit-address-family`	Exit IPv4 labeled-unicast Address Family mode.
`PE1(config-router)# address-family vpnv4 unicast`	Enter vpnv4 unicast address-family mode.
`PE1(config-router-af)# neighbor 31.31.31.31 activate`	Activate the neighbor under vpnv4 unicast address-family.
`PE1(config-router-af)# exit-address-family`	Exit vpnv4 unicast address-family.
`PE1(config-router)# address-family ipv4 vrf vrf1`	Enter ipv4 VRF address-family mode.
`PE1(config-router-af)# redistribute connected`	Redistribute connected networks under VRF address-family.
`PE1(config-router-af)# exit-address-family`	Exit ipv4 VRF address-family.
`PE1(config-router)#exit`	Exit the router mode.
`PE1(config)#commit`	Commit candidate configuration to be running configuration.
`PE1(config)#exit`	Exit the config mode.

P1

`P1(config)#interface lo`	Enter interface mode.
`P1(config-if)# ip address 51.51.51.51/32 secondary`	Assign the secondary IPv4 address on loopback interface.
`P1(config-if)#interface xe15`	Enter interface mode.
`P1(config-if)# ip address 11.1.1.31/24`	Assign the IPv4 address.
`P1(config-if)#interface xe21`	Enter interface mode.
`P1(config-if)# ip address 12.1.1.31/24`	Assign the IPv4 address.
`P1(config-if)#interface xe22`	Enter interface mode.
`P1(config-if)# ip address 13.1.1.1/24`	Assign the IPv4 address.

`P1(config-if)#router ospf 1`	Enter router OSPF mode.
`P1(config-router)# ospf router-id 51.51.51.51`	Configure OSPF router-id (optional).
`P1(config-router)# network 11.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol.
`P1(config-router)# network 12.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol.
`P1(config-router)# network 13.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol.
`P1(config-router)# network 51.51.51.51/32 area 0.0.0.0`	Enable networks for OSPF protocol.
`P1(config-router)#router ldp`	Enter router LDP mode. This is required to enable LDP globally on the router.
`P1(config-router)#router-id 51.51.51.51`	Set the router ID to IP address 51.51.51.51
`P1(config-router)#transport-address ipv4 51.51.51.51`	Configure LDP transport address same as loopback address.
`P1(config-router)#interface xe15`	Enter interface configuration mode.
`P1(config-if)# label-switching`	Configure label-switching on the interface.
`P1(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`P1(config-if)#interface xe21`	Enter interface configuration mode.
`P1(config-if)# label-switching`	Configure label-switching on the interface.
`P1(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`P1(config-if)#exit`	Exit interface mode.
`P1(config)#commit`	Commit candidate configuration to the running configuration.
`P1(config)#exit`	Exit the config mode.

RR1

`#configure terminal`	Enter configure mode.
`RR1(config)#interface lo`	Enter interface mode.
`RR1(config-if)# ip address 31.31.31.31/32 secondary`	Assign the IPv4 address.
`RR1(config-if)#interface xe22`	Exit interface mode.
`RR1(config-if)# ip address 13.1.1.2/24`	Assign the IPv4 address.
`RR1(config-if)#router ospf 1`	Enter router OSPF mode.
`RR1(config-router)# ospf router-id 31.31.31.31`	Configure OSPF router-id explicitly (optional).
`RR1(config-router)# network 13.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol under area 0.
`RR1(config-router)# network 31.31.31.31/32 area 0.0.0.0`	Enable networks for OSPF protocol under area 0.
`RR1(config-router)#router bgp 65000`	Enter BGP router mode.
`RR1(config-router)# bgp router-id 31.31.31.31`	Configure BGP router-id.
`RR1(config-router)# no bgp default ipv4-unicast`	Disable default ipv4-unicast capability exchange with BGP neighbors.

`RR1(config-router)# no bgp inbound-route-filter`	Disable inbound route-filtering for bgp VPNV4 routes. This is required for Route-reflectors.
`RR1(config-router)# neighbor 2.2.2.2 remote-as 65000`	Configure PE2-ASBR as iBGP neighbor.
`RR1(config-router)# neighbor 2.2.2.2 update-source lo`	Configure BGP speaker to use loopback address as source for BGP session.
`RR1(config-router)# neighbor 5.5.5.5 remote-as 65001`	Configure RR2 as an eBGP neighbor.
`RR1(config-router)# neighbor 5.5.5.5 ebgp-multihop`	Enable multihop on eBGP session.
`RR1(config-router)# neighbor 5.5.5.5 update-source lo`	Configure BGP speaker to use loopback address as source for this BGP session.
`RR1(config-router)# neighbor 41.41.41.41 remote-as 65000`	Configure PE1 as an iBGP neighbor.
`RR1(config-router)# neighbor 41.41.41.41 update-source lo`	Configure BGP speaker to use loopback address as source for this BGP session.
`RR1(config-router)# allocate-label all`	Configure this peer to allocate label for all advertised networks.
`RR1(config-router)# address-family ipv4 labeled-unicast`	Enter ipv4 labeled-unicast address-family.
`RR1(config-router-af)# neighbor 2.2.2.2 activate`	Activate PE2-ASBR for this AFI/SAFI.
`RR1(config-router-af)# neighbor 2.2.2.2 route-reflector-client`	Configure PE2-ASBR as Route-reflector client.
`RR1(config-router-af)# neighbor 41.41.41.41 activate`	Activate PE1 for this AFI/SAFI.
`RR1(config-router-af)# neighbor 41.41.41.41 route-reflector-client`	Configure PE1 as Route-reflector client.
`RR1(config-router-af)# exit-address-family`	Exit ipv4 labeled-unicast address-family.
`RR1(config-router)# address-family vpnv4 unicast`	Enter vpnv4 unicast address-family.
`RR1(config-router-af)# neighbor 5.5.5.5 allow-ebgp-vpn`	Allow eBGP VPN route exchange for the RR2 eBGP neighbor.
`RR1(config-router-af)# neighbor 5.5.5.5 activate`	Activate the RR2 eBGP neighbor.
`RR1(config-router-af)# neighbor 5.5.5.5 attribute-unchanged next-hop`	Configure next-hop unchanged for this eBGP neighbor for all vpnv4 NLRIs to keep original next-hop while advertising to this eBGP neighbor.
`RR1(config-router-af)# neighbor 41.41.41.41 activate`	Activate PE1 iBGP neighbor.
`RR1(config-router-af)# neighbor 41.41.41.41 route-reflector-client`	Configure PE1 as Route-reflector client for this AFI/SAFI.
`RR1(config-router-af)# exit-address-family`	Exit Address-family mode.
`RR1(config-router)#exit`	Exit the router mode.
`RR1(config)#commit`	Commit candidate configuration to be running configuration.
`RR1(config)#exit`	Exit the config mode.

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PE2-ASBR

`PE2-ASBR#configure terminal`	Enter configure mode.
`PE2-ASBR(config)#interface lo`	Enter interface mode.
`PE2-ASBR(config-if)# ip address 2.2.2.2/32 secondary`	Assign a secondary IPv4 address to the loopbacl interface.
`PE2-ASBR(config-if)#interface xe20`	Enter interface mode.
`PE2-ASBR(config-if)# ip address 12.1.1.2/24`	Assign an IPv4 address to the interface.
`PE2-ASBR(config-if)#interface xe5`	Enter interface mode.
`PE2-ASBR(config-if)# ip address 20.1.1.2/24`	Assign an IPv4 address to the interface.
`PE2-ASBR(config-if)#ip access-list standard RR1_LO`	Create an IP standard access list to permit RR1s loopbacl address. This is required to redistribute RR1 Lo from OSPF to BGP.
`PE2-ASBR(config-ip-acl-std)# permit host 31.31.31.31`	Permit RR1 loopback address.
`PE2-ASBR(config-ip-acl-std)#ip access-list standard RR2_LO`	Create an IP standard access list to permit RR2 Lo address. This is required to redistribute RR2 Lo from BGP to OSPF.
`PE2-ASBR(config-ip-acl-std)# permit host 5.5.5.5`	Permit RR2s Loopback address.
`PE2-ASBR(config-ip-acl-std)#route-map RR1_LO permit 10`	Create a Route-map to allow RR1-LO address . This is required when redistributing from OSPF to BGP.
`PE2-ASBR(config-route-map)# match ip address RR1_LO`	match the RR1_LO access list.
`PE2-ASBR(config-route-map)#route-map RR2_LO permit 10`	Create a Route-map to allow RR2-LO address . This is required when redistributing from BGP to OSPF.
`PE2-ASBR(config-route-map)# match ip address RR2_LO`	match the RR2_LO access list.
`PE2-ASBR(config-route-map)#router ospf 1`	Enter router OSPF mode.
`PE2-ASBR(config-router)# ospf router-id 2.2.2.2`	Configure OSPF router-id explicitly (optional).
`PE2-ASBR(config-router)# redistribute bgp route-map RR2_LO`	Redistribute RR2's Lo from BGP to OSPF. This is required for eBGP session between RR1 and RR2.
`PE2-ASBR(config-router)# network 2.2.2.2/32 area 0.0.0.0`	Enable OSPF networks/links in area 0.
`PE2-ASBR(config-router)# network 12.1.1.0/24 area 0.0.0.0`	Enable OSPF networks/links in area 0.
`PE2-ASBR(config-router)#router ldp`	Enter Router ldp mode. This is required to enable ldp globally on the router.
`PE2-ASBR(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2
`PE2-ASBR(config-router)#transport-address ipv4 2.2.2.2`	Configure LDP transport address same as loopback address.
`PE2-ASBR(config-router)#interface xe20`	Enter interface mode.
`PE2-ASBR(config-if)# label-switching`	Configure label-switching to enable MPLS forwarding on this interface.
`PE2-ASBR(config-if)# enable-ldp ipv4`	Enable LDP on this interface.
`PE2-ASBR(config-if)#interface xe5`	Enter interface mode.
`PE2-ASBR(config-if)# label-switching`	Configure label-switching to enable MPLS forwarding on this interface.

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`PE2-ASBR(config-if)#router bgp 65000`	Enter router BGP configuration mode.
`PE2-ASBR(config-router)# bgp router-id 2.2.2.2`	Configure BGP router-id.
`PE2-ASBR(config-router)# no bgp default ipv4-unicast`	Configure BGP to disable default exchange of ipv4 unicast AFI/SAFI capability.
`PE2-ASBR (config-router)# address-family ipv4 unicast`	Enter address-family ipv4 unicast mode
`PE2-ASBR(config-router-af)# redistribute ospf route-map RR1_LO`	Redistribute RR1 Lo from OSPF to BGP. This is required for eBGP session between RR1 and RR2.
`PE2-ASBR(config-router-af)#exit`	Exit address-family mode
`PE2-ASBR(config-router)# neighbor 20.1.1.40 remote-as 65001`	Configure PE3-ASBR as eBGP neighbor.
`PE2-ASBR(config-router)# neighbor 20.1.1.40 activate`	Activate PE3-ASBR neighbor for IPv4 unicast AFI/SAFI. This is required to exchange the redistributed RR1 Lo prefix to PE3-ASBR eBGP peer.
`PE2-ASBR(config-router)# neighbor 31.31.31.31 remote-as 65000`	Configure RR1 as an iBGP neighbor.
`PE2-ASBR(config-router)# neighbor 31.31.31.31 update-source lo`	Update the source of the iBGP session to loopbacl address.
`PE2-ASBR(config-router)# allocate-label all`	Configure this command to allocate label for all advertised networks.
`PE2-ASBR(config-router)# address-family ipv4 labeled-unicast`	Enter ipv4 labeled-unicast AFI/SAFI.
`PE2-ASBR(config-router-af)# neighbor 20.1.1.40 activate`	Activate PE3-ASBR neighbor for IPv4 labeled-unicast.
`PE2-ASBR(config-router-af)# neighbor 31.31.31.31 activate`	Activate RR1 neighbor for IPv4 labeled-unicast.
`PE2-ASBR(config-router-af)# neighbor 31.31.31.31 next-hop-self`	Configure next-hop-self for the RR1 neighbor.
`PE2-ASBR(config-router-af)# exit-address-family`	Exit this address-family.
`PE2-ASBR(config-router)#exit`	Exit the router mode.
`PE2-ASBR (config)#commit`	Commit candidate configuration to be running configuration.
`PE2-ASBR(config)#exit`	Exit the config mode.

PE3-ASBR

`#configure terminal`	Enter configure mode.
`PE3-ASBR(config)#interface lo`	Enter interface mode.
`PE3-ASBR(config-if)# ip address 40.40.40.40/32 secondary`	Assign a secondary IPv4 address to the loopbacl interface.
`PE3-ASBR(config-if)#interface xe5`	Enter interface mode.
`PE3-ASBR(config-if)# ip address 20.1.1.40/24`	Assign an IPv4 address to the interface.
`PE3-ASBR(config-if)#interface xe1`	Enter interface mode.
`PE3-ASBR(config-if)# ip address 21.1.1.40/24`	Assign an IPv4 address to the interface.
`PE3-ASBR(config-if)#ip access-list standard RR1_LO`	Create an IP standard access list to permit RR1s loopbacl address. This is required to redistribute RR1 Lo from BGP to OSPF.

PE3-ASBR(config-ip-acl-std)# permit host 31.31.31.31	Permit RR1 loopback address.
PE3-ASBR(config-ip-acl-std)#ip access-list standard RR2_LO	Create an IP standard access list to permit RR2 Lo address. This is required to redistribute RR2 Lo from OSPF to BGP.
PE3-ASBR(config-ip-acl-std)# permit host 5.5.5.5	Permit RR2s Loopback address.
PE3-ASBR(config-ip-acl-std)#route-map RR1_LO permit 10	Create a Route-map to allow RR1-LO address . This is required when redistributing from BGP to OSPF.
PE3-ASBR(config-route-map)# match ip address RR1_LO	match the RR1_LO access list.
PE3-ASBR(config-route-map)#route-map RR2_LO permit 10	Create a Route-map to allow RR2-LO address . This is required when redistributing from OSPF to BGP.
PE3-ASBR(config-route-map)# match ip address RR2_LO	match the RR2_LO access list.
PE3-ASBR(config-route-map)#router ospf 1	Enter router OSPF mode.
PE3-ASBR(config-router)# ospf router-id 40.40.40.40	Configure OSPF router-id explicitly (optional).
PE3-ASBR(config-router)# redistribute bgp route-map RR1_LO	Redistribute RR2's Lo from OSPF to BGP. This is required for eBGP session between RR1 and RR2.
PE3-ASBR(config-router)# network 21.1.1.0/24 area 0.0.0.0	Enable OSPF networks/links in area 0.
PE3-ASBR(config-router)# network 40.40.40.40/32 area 0.0.0.0	Enable OSPF networks/links in area 0.
PE3-ASBR(config-router)#router ldp	Enter Router LDP mode. This is required to enable LDP globally on the router.
PE3-ASBR(config-router)#router-id 40.40.40.40	Set the router ID to IP address 40.40.40.40
PE3-ASBR(config-router)#transport-address ipv4 40.40.40.40	Configure LDP transport address same as loopback address
PE3-ASBR(config-router)#interface xe5	Enter interface mode.
PE3-ASBR(config-if)# label-switching	Configure label-switching to enable MPLS forwarding on this interface.
PE3-ASBR(config-if)#interface xe1	Enter interface mode.
PE3-ASBR(config-if)# label-switching	Configure label-switching to enable MPLS forwarding on this interface.
PE3-ASBR(config-if)# enable-ldp ipv4	Enable LDP on this interface.
PE3-ASBR(config-if)#router bgp 65001	Enter router BGP configuration mode.
PE3-ASBR(config-router)# bgp router-id 40.40.40.40	Configure BGP router-id.
PE3-ASBR(config-router)# no bgp default ipv4-unicast	Configure BGP to disable default exchange of ipv4 unicast AFI/SAFI capability.
PE3-ASBR(config-router)# redistribute ospf route-map RR2_LO	Redistribute RR2 Lo from OSPF to BGP. This is required for eBGP session between RR1 and RR2.
PE3-ASBR(config-router)# neighbor 5.5.5.5 remote-as 65001	Configure RR2 as eBGP neighbor.
PE3-ASBR(config-router)# neighbor 5.5.5.5 update-source lo	Update the source of the iBGP session to loopback address.
PE3-ASBR(config-router)# neighbor 20.1.1.2 remote-as 65000	Configure PE2-ASBR as an eBGP neighbor.

`PE3-ASBR(config-router)# neighbor 20.1.1.2 activate`	Activate PE2-ASBR neighbor for IPv4 unicast AFI/SAFI. This is required to exchange the redistributed RR1 Lo prefix to PE2-ASBR eBGP peer.
`PE3-ASBR(config-router)# allocate-label all`	Configure this command to allocate label for all advertised networks.
`PE3-ASBR(config-router)# address-family ipv4 labeled-unicast`	Enter ipv4 labeled-unicast AFI/SAFI.
`PE3-ASBR(config-router-af)# neighbor 5.5.5.5 activate`	Activate RR1 neighbor for IPv4 labeled-unicast.
`PE3-ASBR(config-router-af)# neighbor 5.5.5.5 next-hop-self`	Configure next-hop-self for the RR2 neighbor.
`PE3-ASBR(config-router-af)# neighbor 20.1.1.2 activate`	Activate PE2-ASBR neighbor for IPv4 labeled-unicast.
`PE3-ASBR(config-router-af)# ex-it-address-family`	Exit this address-family.
`PE3-ASBR(config-router)#exit`	Exit the router mode.
`PE3-ASBR(config)#commit`	Commit candidate configuration to be running configuration.
`PE3-ASBR(config)#exit`	Exit the config mode.

RR2

`#configure terminal`	Enter configure mode.
`RR2(config)#interface lo`	Enter interface mode.
`RR2(config-if)# ip address 5.5.5.5/32 secondary`	Assign the IPv4 address.
`RR2(config-if)#interface xe22`	Enter interface mode.
`RR2(config-if)# ip address 23.1.1.2/24`	Assign the IPv4 address.
`RR2(config-if)#router ospf 1`	Enter router OSPF mode.
`RR2(config-router)# ospf router-id 5.5.5.5`	Configure OSPF router-id explicitly (optional).
`RR2(config-router)# network 5.5.5.5/32 area 0.0.0.0`	Enable networks for OSPF protocol under area 0.
`RR2(config-router)# network 23.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol under area 0.
`RR2(config-router)#router bgp 65001`	Enter BGP router mode.
`RR2(config-router)# bgp router-id 5.5.5.5`	Configure BGP router-id.
`RR2(config-router)# no bgp default ipv4-unicast`	Disable default ipv4-unicast capability exchange with BGP neighbors.
`RR2(config-router)# no bgp inbound-route-filter`	Disable inbound route-filtering for bgp VPNV4 routes. This is required for Route-reflectors.
`RR2(config-router)# neighbor 28.28.28.28 remote-as 65001`	Configure PE2-ASBR as iBGP neighbor.
`RR2(config-router)# neighbor 28.28.28.28 update-source lo`	Configure BGP speaker to use loopback address as source for BGP session.
`RR2(config-router)# neighbor 31.31.31.31 remote-as 65000`	Configure RR2 as an eBGP neighbor.
`RR2(config-router)# neighbor 31.31.31.31 ebgp-multihop`	Enable multihop on eBGP session.

`RR2(config-router)# neighbor 31.31.31.31 update-source lo`	Configure BGP speaker to use loopback address as source for this BGP session.
`RR2(config-router)# neighbor 40.40.40.40 remote-as 65001`	Configure PE1 as an iBGP neighbor.
`RR2(config-router)# neighbor 40.40.40.40 update-source lo`	Configure BGP speaker to use loopback address as source for this BGP session.
`RR2(config-router)# allocate-label all`	Configure this peer to allocate label for all advertised networks.
`RR2(config-router)# address-family ipv4 labeled-unicast`	Enter ipv4 labeled-unicast address-family.
`RR2(config-router-af)# neighbor 28.28.28.28 activate`	Activate PE2-ASBR for this AFI/SAFI.
`RR2(config-router-af)# neighbor 28.28.28.28 route-reflector-client`	Configure PE2-ASBR as Route-reflector client.
`RR2(config-router-af)# neighbor 40.40.40.40 activate`	Activate PE1 for this AFI/SAFI.
`RR2(config-router-af)# neighbor 40.40.40.40 route-reflector-client`	Configure PE1 as Route-reflector client.
`RR2(config-router-af)# exit-address-family`	Exit ipv4 labeled-unicast address-family.
`RR2(config-router)# address-family vpnv4 unicast`	Enter vpnv4 unicast address-family.
`RR2(config-router-af)# neighbor 28.28.28.28 activate`	Allow eBGP vpn route exchange for the RR2 eBGP neighbor.
`RR2(config-router-af)# neighbor 28.28.28.28 route-reflector-client`	Activate the RR2 eBGP neighbor.
`RR2(config-router-af)# neighbor 31.31.31.31 allow-ebgp-vpn`	Configure next-hop unchanged for this eBGP neighbor for all vpnv4 NLRIs to keep original next-hop while advertising to this eBGP neighbor.
`RR2(config-router-af)# neighbor 31.31.31.31 activate`	Activate PE1 iBGP neighbor.
`RR2(config-router-af)# neighbor 31.31.31.31 attribute-unchanged next-hop`	Configure PE1 as Route-reflector client for this AFI/SAFI.
`RR2(config-router-af)# exit-address-family`	Exit Address-family mode.
`RR2(config-router)#exit`	Exit the router mode.
`RR2(config)#commit`	Commit candidate configuration to be running configuration.
`RR2(config)#exit`	Exit the config mode.

P2

`P2(config)#interface lo`	Enter interface mode.
`P2(config-if)# ip address 6.6.6.6/32 secondary`	Assign the secondary IPv4 address on loopback interface.
`P2(config-if)#interface xe22`	Enter interface mode.
`P2(config-if)# ip address 23.1.1.1/24`	Assign the IPv4 address.
`P2(config-if)#interface xe0`	Enter interface mode.
`P2(config-if)# ip address 21.1.1.5/24`	Assign the IPv4 address.
`P2(config-if)#interface xe11`	Enter interface mode.

`P2(config-if)# ip address 22.1.1.5/24`	Assign the IPv4 address.
`P2(config-if)#router ospf 1`	Enter router OSPF mode.
`P2(config-router)# ospf router-id 6.6.6.6`	Configure OSPF router-id (optional).
`P2(config-router)# network 6.6.6.6/32 area 0.0.0.0`	Enable networks for OSPF protocol.
`P2(config-router)# network 21.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol.
`P2(config-router)# network 22.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol.
`P2(config-router)# network 23.1.1.0/24 area 0.0.0.0`	Enable networks for OSPF protocol.
`P2(config-router)#router ldp`	Enter router ldp mode. This is required to enable LDP globally on the router.
`P2(config-router)#router-id 6.6.6.6`	Set the router ID to IP address 6.6.6.6
`P2(config-router)#transport-address ipv4 6.6.6.6`	Configure LDP transport address same as loopback address.
`P2(config-router)#interface xe0`	Enter interface configuration mode.
`P2(config-if)# label-switching`	Configure label-switching on the interface.
`P2(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`P2(config-if)#interface xe11`	Enter interface configuration mode.
`P2(config-if)# label-switching`	Configure label-switching on the interface.
`P2(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`P2(config-if)#exit`	Exit interface mode.
`P2(config)#commit`	Commit candidate configuration to be running configuration.
`P2(config)#exit`	Exit the config mode.

PE4

`#configure terminal`	Enter configure mode.
`PE4(config)#interface lo`	Enter interface mode.
`PE4(config-if)# ip address 28.28.28.28/32 secondary`	Assign the secondary IPv4 address on the loopback interface.
`PE4(config-if)#ip vrf vrf1`	Create a new VRF named vrf1.
`PE4(config-vrf)# rd 1:1`	Assign the route distinguisher (RD) value as 1:1.
`PE4(config-vrf)# route-target both 1:1`	Configure import and export route-target values.
`PE4(config-vrf)#interface xe21`	Enter interface mode.
`PE4(config-if)# ip vrf forwarding vrf1`	Bind the interface connected to the CE router with VRF vrf1.
`PE4(config-if)# ip address 30.1.1.1/24`	Assign the IPv4 address.
`PE4(config-if)#interface xe11`	Enter interface mode.
`PE4(config-if)# ip address 22.1.1.28/24`	Assign the IPv4 address.
`PE4(config-if)#router ospf 1`	Enter router OSPF mode.
`PE4(config-router)# ospf router-id 28.28.28.28`	Configure OSPF router id same as loopback ip address.
`PE4(config-router)# network 22.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.

`PE4(config-router)# network 28.28.28.28/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`PE4(config-router)#router ldp`	Enter router LDP mode.
`PE4(config-router)#router-id 28.28.28.28`	Set the router ID to IP address 28.28.28.28
`PE4(config-router)#transport-address ipv4 28.28.28.28`	Configure LDP transport address same as loopback address.
`PE4(config-router)#interface xe11`	Enter interface mode.
`PE4(config-if)# label-switching`	Enable label switching in interface.
`PE4(config-if)# enable-ldp ipv4`	Enable LDP in interface.
`PE4(config-if)#router bgp 65001`	Enter BGP router mode.
`PE4(config-router)# bgp router-id 28.28.28.28`	Configure BGP router-id.
`PE4(config-router)# no bgp default ipv4-unicast`	Configure BGP peer to have no ipv4 unicast capability exchange by default.
`PE4(config-router)# address-family ipv4 unicast`	Enter the IPv4 unicast address family.
`PE4(config-router-af)# network 28.28.28.28/32`	advertise the network of this BGP speaker.
`PE4(config-router-af)# exit-address-family`	Exit address family mode.
`PE4(config-router)# neighbor 5.5.5.5 remote-as 65001`	configure neighbor with remote AS.
`PE4(config-router)# neighbor 5.5.5.5 update-source lo`	Update the loopback as the source of BGP session.
`PE4(config-router)# allocate-label all`	Allocate the label for all advertised networks.
`PE4(config-router)# address-family ipv4 labeled-unicast`	Enter the IPv4 labeled-unicast address family.
`PE4(config-router-af)# neighbor 5.5.5.5 activate`	Activate the neighbor under the address-family.
`PE4(config-router-af)# exit-address-family`	Exit IPv4 labeled-unicast Address Family mode.
`PE4(config-router)# address-family vpnv4 unicast`	Enter vpnv4 unicast address-family mode.
`PE4(config-router-af)# neighbor 5.5.5.5 activate`	Activate the neighbor under vpnv4 unicast address-family.
`PE4(config-router-af)# exit-address-family`	Exit vpnv4 unicast address-family.
`PE4(config-router)# address-family ipv4 vrf vrf1`	Enter ipv4 VRF address-family mode.
`PE4(config-router-af)# redistribute connected`	Redistribute connected networks under VRF address-family.
`PE4(config-router-af)# exit-address-family`	Exit ipv4 VRF address-family.
`PE4(config-router)#exit`	Exit the router mode.
`PE4(config)#commit`	Commit candidate configuration to be running configuration.
`PE4(config)#exit`	Exit the config mode.

Validation

PE1

```
PE1#show ip bgp labeled-unicast summary
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 5
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
31.31.31.31              4 65000 5920       5932       5      0      0
1d15h58m             3

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop        In Label     Out Label
*>i 5.5.5.5/32       2.2.2.2          24963        24965
*>i 28.28.28.28/32   2.2.2.2          24965        24964
*>i 31.31.31.31/32   2.2.2.2          24967        24961
*>  41.41.41.41/32   0.0.0.0          24961          -

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
   L>    2.2.2.2/32         4        0          Yes   LSP_DEFAULT    24321
xe15        No        11.1.1.31
   L>    5.5.5.5/32         6        0          Yes   LSP_DEFAULT    24324
xe15        No        11.1.1.31
   B     5.5.5.5/32         7        0          Yes   LSP_DEFAULT    24965
-           No        2.2.2.2
   L>    12.1.1.0/24        2        0          Yes   LSP_DEFAULT     3
xe15        No        11.1.1.31
   L>    13.1.1.0/24        3        0          Yes   LSP_DEFAULT     3
e15        No        11.1.1.31
   B>    28.28.28.28/32     9        0          Yes   LSP_DEFAULT    24964
-           No        2.2.2.2
   L>    31.31.31.31/32     5        0          Yes   LSP_DEFAULT    24322
xe15        No        11.1.1.31
   B     31.31.31.31/32     11       0          Yes   LSP_DEFAULT    24961
-           No        2.2.2.2
   L>    51.51.51.51/32     1        0          Yes   LSP_DEFAULT     3
xe15        No        11.1.1.31

PE1#show ip bgp vpnv4 all summary
```

```
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 2
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
31.31.31.31              4 65000 5928       5940       2      0      0
1d16h01m               1

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*> l 10.1.1.0/24      0.0.0.0              0         100           32768    ?
*>il 30.1.1.0/24      28.28.28.28          0         100           0
65001 ?
 Announced routes count = 1
 Accepted routes count = 1
Route Distinguisher: 1:1
*>il 30.1.1.0/24      28.28.28.28          0         100           0
65001 ?
 Announced routes count = 0
 Accepted routes count = 1

PE1#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
C    *>  10.1.1.0/24 is directly connected, xe23, 1d15h59m
B    *>  30.1.1.0/24 [200/0] via 28.28.28.28, 1d15h47m

Gateway of last resort is not set
```

P1

```
P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown
```

```
Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                       LSP-Type
  L>  2.2.2.2/32       2          24321      3         N/A       xe21
12.1.1.2                  LSP_DEFAULT
  L>  41.41.41.41/32    1          24320      3         N/A       xe15
11.1.1.2                  LSP_DEFAULT
  L>  31.31.31.31/32    4          24323     Nolabel    N/A       N/A
127.0.0.1                 LSP_DEFAULT
  L>  31.31.31.31/32    3          24322     Nolabel    N/A       N/A
127.0.0.1                 LSP_DEFAULT
  L>  5.5.5.5/32       5          24324     Nolabel    N/A       N/A
127.0.0.1                 LSP_DEFAULT
```

RR1

```
RR1#show ip route ospf
IP Route Table for VRF "default"
O            2.2.2.2/32 [110/3] via 13.1.1.1, xe22, 1d16h37m
O E2         5.5.5.5/32 [110/1] via 13.1.1.1, xe22, 1d16h35m
O            11.1.1.0/24 [110/2] via 13.1.1.1, xe22, 1d16h37m
O            12.1.1.0/24 [110/2] via 13.1.1.1, xe22, 1d16h37m
O            41.41.41.41/32 [110/3] via 13.1.1.1, xe22, 1d16h37m
O            51.51.51.51/32 [110/2] via 13.1.1.1, xe22, 1d16h37m

Gateway of last resort is not set

RR1#sho ip bgp labeled-unicast summary
BGP router identifier 31.31.31.31, local AS number 65000
BGP table version is 9
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
2.2.2.2                  4 65000 7514       7654       9      0      0
1d16h11m              3
41.41.41.41              4 65000 5961       5951       9      0      0
1d16h11m              1

Total number of neighbors 2

Total number of Established sessions 2

RR1#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop        In Label     Out Label
*>i 5.5.5.5/32       2.2.2.2          24320        24965
*>i 28.28.28.28/32   2.2.2.2          24323        24964
*>i 31.31.31.31/32   2.2.2.2          24327        24961
*>i 41.41.41.41/32   41.41.41.41      24326        24961

RR1#show ip bgp vpnv4 all summary
BGP router identifier 31.31.31.31, local AS number 65000
BGP table version is 3
2 BGP AS-PATH entries
0 BGP community entries
```

```
Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
5.5.5.5                 4 65001 5729       5725       3      0      0
1d15h56m              1
41.41.41.41             4 65000 5962       5953       3      0      0
1d16h12m              1

Total number of neighbors 2

Total number of Established sessions 2

RR1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop           Metric    LocPrf      Weight Path
Route Distinguisher: 1:1
*>il 10.1.1.0/24      41.41.41.41          0         100            0        ?
*>   30.1.1.0/24      28.28.28.28          0         100            0
65001 ?
 Announced routes count = 0
 Accepted routes count = 2
```

PE2-ASBR

```
PE2-ASBR#show ip bgp labeled-unicast summary
BGP router identifier 2.2.2.2, local AS number 65000
BGP table version is 6
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
20.1.1.40               4 65001 5884       5976       6      0      0
1d16h37m              2
31.31.31.31             4 65000 5790       5794       6      0      0
1d16h15m              1

Total number of neighbors 2

Total number of Established sessions 2

PE2-ASBR#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop        In Label     Out Label
*>  5.5.5.5/32       20.1.1.40         24965        24965
*>  28.28.28.28/32   20.1.1.40         24964        24962
*>  31.31.31.31/32   12.1.1.31         24961          -
*>i 41.41.41.41/32   41.41.41.41       24967        24961

PE2-ASBR#sho mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
```

```
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                          LSP-Type
  B>  5.5.5.5/32       6          24965      24965      N/A       N/A
20.1.1.40                LSP_DEFAULT
  B>  28.28.28.28/32    5          24964      24962      N/A       N/A
20.1.1.40                LSP_DEFAULT
  B>  31.31.31.31/32    2          24961      Nolabel    N/A       N/A
127.0.0.1                LSP_DEFAULT
  B>  41.41.41.41/32    8          24967      24961      N/A       N/A
41.41.41.41              LSP_DEFAULT

PE2-ASBR#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
   B>    5.5.5.5/32        8       0          Yes   LSP_DEFAULT    24965
xe5       No        20.1.1.40
   L>    11.1.1.0/24        1       0          Yes   LSP_DEFAULT    3
xe20        No        12.1.1.31
   L>    13.1.1.0/24        2       0          Yes   LSP_DEFAULT    3
xe20        No        12.1.1.31
   B>    28.28.28.28/32     7       0          Yes   LSP_DEFAULT    24962
xe5       No        20.1.1.40
   L>    31.31.31.31/32     5       0          Yes   LSP_DEFAULT    24323
xe20        No        12.1.1.31
   L>    41.41.41.41/32     3       0          Yes   LSP_DEFAULT    24320
xe20        No        12.1.1.31
   B    41.41.41.41/32     10      0          Yes   LSP_DEFAULT    24961
-           No        41.41.41.41
   L>    51.51.51.51/32     4       0          Yes   LSP_DEFAULT    3
xe20        No        12.1.1.31

PE2-ASBR#show ip route bgp
IP Route Table for VRF "default"
B            5.5.5.5/32 [20/3] via 20.1.1.40, xe5, 1d16h38m
B            28.28.28.28/32 [20/0] via 20.1.1.40, xe5, 1d16h39m

Gateway of last resort is not set

PE2-ASBR#show ip route ospf
IP Route Table for VRF "default"
O            11.1.1.0/24 [110/2] via 12.1.1.31, xe20, 1d16h59m
O            13.1.1.0/24 [110/2] via 12.1.1.31, xe20, 1d16h59m
O            31.31.31.31/32 [110/3] via 12.1.1.31, xe20, 1d16h41m
O            41.41.41.41/32 [110/3] via 12.1.1.31, xe20, 1d16h59m
O            51.51.51.51/32 [110/2] via 12.1.1.31, xe20, 1d16h59m

Gateway of last resort is not set

PE2-ASBR#show ip route connected
IP Route Table for VRF "default"
```

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```
C             2.2.2.2/32 is directly connected, lo, 1d18h27m
C             12.1.1.0/24 is directly connected, xe20, 1d18h27m
C             20.1.1.0/24 is directly connected, xe5, 1d18h27m
C             127.0.0.0/8 is directly connected, lo, 1d19h32m

Gateway of last resort is not set
```

PE3-ASBR

```
 PE3-ASBR#show ip bgp labeled-unicast summary
BGP router identifier 40.40.40.40, local AS number 65001
BGP table version is 7
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
5.5.5.5                  4 65001 5729       5736       7      0      0
1d16h46m              1
20.1.1.2                 4 65000 5731       5739       7      0      0
1d16h46m              2

Total number of neighbors 2

Total number of Established sessions 2

PE3-ASBR#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop        In Label     Out Label
*>  5.5.5.5/32       21.1.1.5         24965          -
*>i 28.28.28.28/32   28.28.28.28      24962        24321
*>  31.31.31.31/32   20.1.1.2         24964        24961
*>  41.41.41.41/32   20.1.1.2         24967        24967

PE3-ASBR#sho mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                     LSP-Type
  B>   31.31.31.31/32    6         24964      24961      N/A       N/A
20.1.1.2                 LSP_DEFAULT
  B>   28.28.28.28/32    4         24962      24321      N/A       N/A
28.28.28.28              LSP_DEFAULT
  B>   41.41.41.41/32    9         24967      24967      N/A       N/A
20.1.1.2                 LSP_DEFAULT
  B>   5.5.5.5/32       7         24965     Nolabel    N/A       N/A
127.0.0.1                LSP_DEFAULT

PE3-ASBR#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
```

```
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
   L>   5.5.5.5/32         5       0          Yes   LSP_DEFAULT    24320
xe1        No        21.1.1.5
   L>   6.6.6.6/32         6       0          Yes   LSP_DEFAULT    3
xe1        No        21.1.1.5
   L>   22.1.1.0/24        7       0          Yes   LSP_DEFAULT    3
xe1        No        21.1.1.5
   L>   23.1.1.0/24        8       0          Yes   LSP_DEFAULT    3
xe1        No        21.1.1.5
   L>   28.28.28.28/32     9       0          Yes   LSP_DEFAULT    24321
xe1        No        21.1.1.5
   B    28.28.28.28/32     2       0          Yes   LSP_DEFAULT    24321
-           No        28.28.28.28
   B>   31.31.31.31/32     4       0          Yes   LSP_DEFAULT    24961
xe5        No        20.1.1.2
   B>   41.41.41.41/32     11      0          Yes   LSP_DEFAULT    24967
xe5        No        20.1.1.2

PE3-ASBR#show ip route bgp
IP Route Table for VRF "default"
B            31.31.31.31/32 [20/3] via 20.1.1.2, xe5, 1d16h46m
B            41.41.41.41/32 [20/0] via 20.1.1.2, xe5, 1d16h23m

Gateway of last resort is not set

PE3-ASBR#show ip route ospf
IP Route Table for VRF "default"
O            5.5.5.5/32 [110/3] via 21.1.1.5, xe1, 1d16h54m
O            6.6.6.6/32 [110/2] via 21.1.1.5, xe1, 1d16h55m
O            22.1.1.0/24 [110/2] via 21.1.1.5, xe1, 1d16h55m
O            23.1.1.0/24 [110/2] via 21.1.1.5, xe1, 1d16h54m
O            28.28.28.28/32 [110/3] via 21.1.1.5, xe1, 1d16h55m

PE3-ASBR#show ip route connected
IP Route Table for VRF "default"
C            20.1.1.0/24 is directly connected, xe5, 1d16h55m
C            21.1.1.0/24 is directly connected, xe1, 1d16h55m
C            40.40.40.40/32 is directly connected, lo, 1d16h55m
C            127.0.0.0/8 is directly connected, lo, 1d19h39m

Gateway of last resort is not set
```

RR2

```
RR2#show ip bgp labeled-unicast summary
BGP router identifier 5.5.5.5, local AS number 65001
BGP table version is 10
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS    MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
28.28.28.28              4 65001 5795       5815      10      0      0
1d17h00m               1
40.40.40.40              4 65001 5779       5787      10      0      0
1d16h54m               3
```

```
Total number of neighbors 2

Total number of Established sessions 2

RR2#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop        In Label     Out Label
*>i 5.5.5.5/32       40.40.40.40       24325        24965
*>i 28.28.28.28/32   28.28.28.28       24322        24321
*>i 31.31.31.31/32   40.40.40.40       24324        24964
*>i 41.41.41.41/32   40.40.40.40       24327        24967

RR2#show ip bgp vpnv4 all summary
BGP router identifier 5.5.5.5, local AS number 65001
BGP table version is 3
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
28.28.28.28              4 65001 5796       5815       3      0      0
1d17h00m               1
31.31.31.31              4 65000 5769       5776       3      0      0
1d16h16m               1

Total number of neighbors 2

Total number of Established sessions 2

RR2#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1
*>   10.1.1.0/24      41.41.41.41          0         100           0
65000 ?
*>il 30.1.1.0/24      28.28.28.28          0         100           0        ?
 Announced routes count = 0
 Accepted routes count = 2

RR2#show ip route ospf
IP Route Table for VRF "default"
O            6.6.6.6/32 [110/2] via 23.1.1.1, xe22, 1d17h02m
O            21.1.1.0/24 [110/2] via 23.1.1.1, xe22, 1d17h02m
O            22.1.1.0/24 [110/2] via 23.1.1.1, xe22, 1d17h02m
O            28.28.28.28/32 [110/3] via 23.1.1.1, xe22, 1d17h02m
O E2         31.31.31.31/32 [110/1] via 23.1.1.1, xe22, 1d16h54m
O            40.40.40.40/32 [110/3] via 23.1.1.1, xe22, 1d17h02m

Gateway of last resort is not set
```

P2

```
P2#show mpls ilm-table
```

```
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                      LSP-Type
  L>   5.5.5.5/32       3          24322      Nolabel    N/A       N/A
127.0.0.1                 LSP_DEFAULT
  L>   5.5.5.5/32       1          24320      Nolabel    N/A       N/A
127.0.0.1                 LSP_DEFAULT
  L>   28.28.28.28/32    2          24321      3         N/A       xe11
22.1.1.28                 LSP_DEFAULT
  L>   31.31.31.31/32    4          24323      Nolabel    N/A       N/A
127.0.0.1                 LSP_DEFAULT
  L>   40.40.40.40/32    5          24324      3         N/A       xe0
21.1.1.40                 LSP_DEFAULT
```

PE4

```
PE4#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop         In Label     Out Label
*>i 5.5.5.5/32       40.40.40.40       24325        24965
*>  28.28.28.28/32   0.0.0.0           24321          -
*>i 31.31.31.31/32   40.40.40.40       24324        24964
*>i 41.41.41.41/32   40.40.40.40       24327        24967

PE4#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
   L>    5.5.5.5/32          4       0          Yes   LSP_DEFAULT    24322
xe11        No        22.1.1.5
   B     5.5.5.5/32          3       0          Yes   LSP_DEFAULT    24965
-           No        40.40.40.40
   L>    6.6.6.6/32          5       0          Yes   LSP_DEFAULT    3
xe11        No        22.1.1.5
   L>    21.1.1.0/24         6       0          Yes   LSP_DEFAULT    3
xe11        No        22.1.1.5
   L>    23.1.1.0/24         7       0          Yes   LSP_DEFAULT    3
xe11        No        22.1.1.5
   L>    31.31.31.31/32      8       0          Yes   LSP_DEFAULT    24323
xe11        No        22.1.1.5
   B     31.31.31.31/32      2       0          Yes   LSP_DEFAULT    24964
-           No        40.40.40.40
   L>    40.40.40.40/32      9       0          Yes   LSP_DEFAULT    24324
xe11        No        22.1.1.5
   B>    41.41.41.41/32      11      0          Yes   LSP_DEFAULT    24967
-           No        40.40.40.40

PE4#show ip bgp vpnv4 all summary
```

```
BGP router identifier 28.28.28.28, local AS number 65001
BGP table version is 2
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
5.5.5.5                  4 65001 5792       5781       2      0      0
1d17h08m               1

Total number of neighbors 1

Total number of Established sessions 1

PE4#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop           Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*>il 10.1.1.0/24      41.41.41.41         0        100           0
65000 ?
*> l 30.1.1.0/24      0.0.0.0             0        100           32768    ?
 Announced routes count = 1
 Accepted routes count = 1
Route Distinguisher: 1:1
*>il 10.1.1.0/24      41.41.41.41         0        100           0
65000 ?
 Announced routes count = 0
 Accepted routes count = 1

PE4#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
B    *>  10.1.1.0/24 [200/0] via 41.41.41.41, 1d16h23m
C    *>  30.1.1.0/24 is directly connected, xe21, 1d16h35m

Gateway of last resort is not set
```

Inter-AS VPN Option-C Configuration (Without RR)

This sub-option enables VPNv4 routes exchange between the Provider Edge Routers of different AS'es and thus requires

1. Remote PE loopback addresses to be known in the AS - This is accomplished using BGP-LU and is advertised inside the AS using the Route-reflector and outside the AS using the eBGP Peering between the ASBRs.

2. Next-hop attribute should be changed when ASBR advertises the remote PE's Loopback address as LU route to the RR. This is accomplished using the configuration "next-hop self" for the iBGP RR neighbor.

3. MP-eBGP session between the two PE's in different AS's to exchange the VPNv4 routes.

(1) and (2) enables an end to end LSP between the two PE's which needs to run the L3VPN service and (3) enables the PE's in different AS'es to form BGP neighborship with each other and successfully exchange the VPNv4 Routes.

Topology

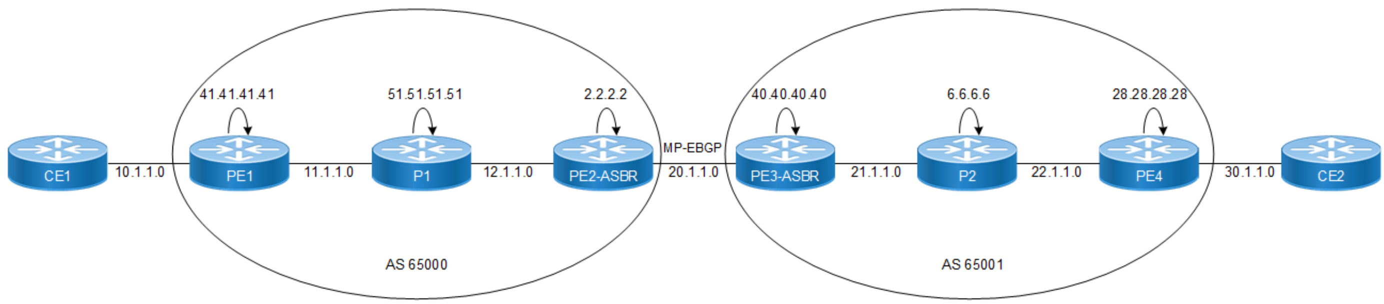

Figure 14-5: InterAS-VPN Option-C without RR

PE1

`#configure terminal`	Enter configure mode.
`PE1(config)#interface lo`	Enter interface mode.
`PE1(config-if)#ip address 41.41.41.41/32 secondary`	Assign the IPv4 address.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config)#ip vrf vrf1`	Create a new VRF named vrf1.
`PE1(config-vrf)#rd 1:1`	Assign the route distinguisher (RD) value as 1:1.
`PE1(config-vrf)#route-target both 1:1`	Configure import and export RT for this VRF.
`PE1(config-vrf)#exit`	Exit interface mode.
`PE1(config)#interface xe23`	Enter interface mode.
`PE1(config-if)#ip vrf forwarding vrf1`	Bind the interface connected to the CE router with VRF vrf1.
`PE1(config-if)#ip address 10.1.1.1/24`	Assign the IPv4 address.
`PE1(config)#interface xe15`	Enter interface mode.
`PE1(config-if)#ip address 11.1.1.41/24`	Assign the IPv4 address.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config)#router ospf 1`	Enter router OSPF mode.
`PE1(config-router)#ospf router-id 41.41.41.41`	Configure OSPF router id same as loopback ip address.
`PE1(config-router)#network 11.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`PE1(config-router)#network 41.41.41.41/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`PE1(config-router)#exit`	Exit OSPF router mode.
`PE1(config-router)#router ldp`	Enter router LDP mode.

`PE1(config-router)#router-id 41.41.41.41`	Set the router ID to IP address 41.41.41.41
`PE1(config-router)#transport-address ipv4 41.41.41.41`	Configure LDP transport address same as loopback address
`PE1(config-router)#exit`	Exit LDP mode.
`(config)#interface xe15`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching in interface.
`(config-if)#enable-ldp ipv4`	Enable LDP in interface.
`(config-if)#exit`	Exit interface mode.
`PE1(config-if)#router bgp 65000`	Enter BGP router mode.
`PE1(config-router)# bgp router-id 41.41.41.41`	Configure BGP router-id.
`PE1(config-router)# no bgp default ipv4-unicast`	Configure BGP peer to have no ipv4 unicast capability exchange by default.
`PE1(config-router)# address-family ipv4 unicast`	Enter address-family ipv4 unicast.
`PE1(config-router-af)# network 41.41.41.41/32`	Advertise loopback address.
`PE1(config-router-af)# exit-address-family`	Exit address-family ipv4 labeled-unicast.
`PE1(config-router)# neighbor 2.2.2.2 remote-as 65000`	Configure PE2-ASBR1 as an iBGP peer.
`PE1(config-router)# neighbor 2.2.2.2 update-source lo`	Update the source as loopback for iBGP peering with the remote PE2 router.
`PE1(config-router)# neighbor 28.28.28.28 remote-as 65001`	Configure PE4 as an eBGP peer.
`PE1(config-router)# neighbor 28.28.28.28 ebgp-multihop`	Configure eBGP multichip for eBGP peer PE4.
`PE1(config-router)# neighbor 28.28.28.28 update-source lo`	Update the source as loopback for eBGP peering with the remote PE4 router.
`PE1(config-router)# allocate-label all`	Configure allocate-label.
`PE1(config-router)# address-family ipv4 labeled-unicast`	Enter address-family ipv4 labeled-unicast.
`PE1(config-router-af)# neighbor 2.2.2.2 activate`	Activate iBGP neighbor.
`PE1(config-router-af)# exit-address-family`	Exit address-family ipv4 labeled-unicast.
`PE1(config-router)# address-family vpnv4 unicast`	Enter address-family vpnv4.
`PE1(config-router-af)# neighbor 28.28.28.28 allow-ebgp-vpn`	Configure allow-ebgp-vpn for ebgp neighbor PE4.
`PE1(config-router-af)# neighbor 28.28.28.28 activate`	Activate eBGP neighbor PE4.
`PE1(config-router-af)# exit-address-family`	Exit address-family vpnv4.
`PE1(config-router)# address-family ipv4 vrf vrf1`	Enter the IPv4 address family for VRF vrf1.
`PE1(config-router-af)# redistribute connected`	Redistribute connected route.
`PE1(config-router-af)# exit-address-family`	Exit IPv4 VRF Address Family mode.
`PE1(config-router)#exit`	Exit the router mode.

`PE1(config)#commit`	Commit candidate configuration to be running configuration.
`PE1(config)#exit`	Exit the config mode.

P1

`P1#configure terminal`	Enter configure mode.
`P1(config)#interface lo`	Enter interface mode.
`P1(config-if)# ip address 51.51.51.51/32 secondary`	Assign the IPv4 address.
`P1(config-if)#exit`	Exit interface mode.
`P1(config)#interface xe15`	Enter interface mode.
`P1(config-if)#ip address 11.1.1.31/24`	Assign the IPv4 address.
`P1(config-if)#exit`	Exit interface mode.
`P1(config)#interface xe21`	Enter interface mode.
`P1(config-if)#ip address 12.1.1.31/24`	Assign the IPv4 address.
`P1(config-if)#exit`	Exit interface mode.
`P1(config)#router ospf 1`	Enter router OSPF mode.
`P1(config-router)#ospf router-id 51.51.51.51`	Configure OSPF router id same as loopback ip address.
`P1(config-router)#network 11.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`P1(config-router)#network 12.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`P1(config-router)#network 51.51.51.51/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`P1(config-router)#exit`	Exit router OSPF mode.
`P1(config-router)#router ldp`	Enter router LDP mode.
`P1(config-router)#router-id 51.51.51.51`	Set the router ID to IP address 51.51.51.51
`P1(config-router)#transport-address ipv4 51.51.51.51`	Configure LDP transport address same as loopback address
`P1(config-router)#exit`	Exit LDP mode.
`P1(config)#interface xe15`	Enter interface mode.
`P1(config-if)#label-switching`	Enable label switching in interface.
`P1(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`P1(config-if)#exit`	Exit interface mode.
`P1(config)#interface xe21`	Enter interface mode.
`P1(config-if)#label-switching`	Enable label switching in interface.
`P1(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`P1(config-if)#exit`	Exit interface mode.
`P1(config)#commit`	Commit candidate configuration to be running configuration.
`P1(config)#exit`	Exit the config mode.

PE2-ASBR1

`#configure terminal`	Enter configure mode.
`PE2-ASBR(config)#interface lo`	Enter interface mode.
`PE2-ASBR(config-if)#ip address 2.2.2.2/32 secondary`	Assign the IPv4 address.
`PE2-ASBR(config-if)#exit`	Exit interface mode.
`PE2-ASBR(config)#router ospf 1`	Enter router OSPF mode.
`PE2-ASBR(config-router)#ospf router-id 2.2.2.2`	Configure OSPF router id same as loopback ip address.
`PE2-ASBR(config-router)#network 2.2.2.2/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`PE2-ASBR(config-router)#network 12.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`PE2-ASBR(config-router)#exit`	Exit router OSPF mode.
`PE2-ASBR(config-router)#router ldp`	Enter router LDP mode.
`PE2-ASBR(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2
`PE2-ASBR(config-router)#transport-address ipv4 2.2.2.2`	Configure LDP transport address same as loopback address.
`PE2-ASBR(config-router)#exit`	Exit LPD mode.
`PE2-ASBR(config)#interface xe5`	Enter interface mode.
`PE2-ASBR(config-if)#ip address 20.1.1.2/24`	Assign the IPv4 address.
`PE2-ASBR(config-if)#label-switching`	Enable label switching in interface.
`PE2-ASBR(config-if)#exit`	Exit interface mode.
`PE2-ASBR(config)#interface xe20`	Enter interface mode.
`PE2-ASBR(config-if)#ip address 12.1.1.2/24`	Assign the IPv4 address.
`PE2-ASBR(config-if)#label-switching`	Enable label switching in interface.
`PE2-ASBR(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`PE2-ASBR(config-if)#exit`	Exit interface mode
`PE2-ASBR(config-if)#router bgp 65000`	Enter BGP router mode.
`PE2-ASBR(config-router)# bgp router-id 2.2.2.2`	Configure BGP router-id.
`PE2-ASBR(config-router)# no bgp default ipv4-unicast`	Configure BGP to have no default ipv4 unicast capability exchange between neighbors.
`PE2-ASBR(config-router)# neighbor 20.1.1.40 remote-as 65001`	Configure PE3-ASBR2 as an eBGP peer.
`PE2-ASBR(config-router)# neighbor 41.41.41.41 remote-as 65000`	Configure PE1 as an iBGP peer.
`PE2-ASBR(config-router)# neighbor 41.41.41.41 update-source lo`	Update the source as loopback for iBGP peering with the remote PE1 router.
`PE2-ASBR(config-router)# allocate-label all`	Configure allocate-label.
`PE2-ASBR(config-router)# address-family ipv4 labeled-unicast`	Enter address-family ipv4 labeled-unicast.
`PE2-ASBR(config-router-af)# neighbor 20.1.1.40 activate`	Activate eBGP neighbor PE3-ASBR2.

PE2-ASBR(config-router-af)# neighbor 41.41.41.41 activate	Activate iBGP neighbor PE1.
PE2-ASBR(config-router-af)# neighbor 41.41.41.41 next-hop-self	Configure next-hop-self for iBGP neighbor PE1.
PE2-ASBR(config-router-af)# exit-address-family	Exit address-family ipv4 labeled-unicast.
PE2(config-router)#exit	Exit the router mode.
PE2(config)#commit	Commit candidate configuration to be running configuration.
PE2(config)#exit	Exit the config mode.

PE3-ASBR

PE3-ASBR#configure terminal	Enter configure mode.
PE3-ASBR(config)#interface lo	Enter interface mode.
PE3-ASBR(config-if)#ip address 40.40.40.40/32 secondary	Assign the IPv4 address.
PE3-ASBR(config-if)#exit	Exit interface mode.
PE3-ASBR(config)#interface xe5	Enter interface mode.
PE3-ASBR(config-if)#ip address 20.1.1.40/24	Assign the IPv4 address.
PE3-ASBR(config-if)#exit	Exit interface mode.
PE3-ASBR(config)#interface xe1	Enter interface mode.
PE3-ASBR(config-if)#ip address 21.1.1.40/24	Assign the IPv4 address.
PE3-ASBR(config-if)#exit	Exit interface mode.
PE3-ASBR(config)#router ospf 1	Enter router OSPF mode.
PE3-ASBR(config-router)#ospf router-id 40.40.40.40	Configure OSPF router id same as loopback ip address.
PE3-ASBR(config-router)#network 21.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE3-ASBR(config-router)#network 40.40.40.40/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE3-ASBR(config-router)#exit	Exit router OSPF mode.
PE3-ASBR(config-router)#router ldp	Enter router LDP mode.
PE3-ASBR(config-router)#router-id 40.40.40.40	Set the router ID to IP address 40.40.40.40
PE3-ASBR(config-router)#transport-address ipv4 40.40.40.40	Configure LDP transport address same as loopback address
PE3-ASBR(config)#interface xe1	Enter interface mode.
PE3-ASBR(config-if)#label-switching	Enable label switching in interface.
PE3-ASBR(config-if)#enable-ldp ipv4	Enable LDP on the interface.
PE3-ASBR(config)#interface xe5	Enter interface mode.
PE3-ASBR(config-if)#label-switching	Enable label switching in interface.
PE3-ASBR(config-if)#router bgp 65001	Enter BGP router mode.
PE3-ASBR(config-router)# bgp router-id 40.40.40.40	Configure BGP router-id.

`PE3-ASBR(config-router)# no bgp default ipv4-unicast`	Configure BGP to have no default ipv4 unicast capability exchange with the neighbors.
`PE3-ASBR(config-router)# neighbor 20.1.1.2 remote-as 65000`	Configure PE2-ASBR as an eBGP peer.
`PE3-ASBR(config-router)# neighbor 28.28.28.28 remote-as 65001`	Configure PE4 as an iBGP peer.
`PE3-ASBR(config-router)# neighbor 28.28.28.28 update-source lo`	Update the source as loopback for iBGP peering with the remote PE4 router.
`PE3-ASBR(config-router)# allocate-label all`	Configure allocate-label.
`PE3-ASBR(config-router)# address-family ipv4 labeled-unicast`	Enter address-family ipv4 labeled-unicast.
`PE3-ASBR(config-router-af)# neighbor 20.1.1.2 activate`	Activate eBGP neighbor PE2-ASBR1.
`PE3-ASBR(config-router-af)# neighbor 28.28.28.28 activate`	Activate iBGP neighbor PE4.
`PE3-ASBR(config-router-af)# neighbor 28.28.28.28 next-hop-self`	Configure next-hop-self for iBGP neighbor PE4.
`PE3-ASBR(config-router-af)# exit-address-family`	Exit address-family ipv4 labeled-unicast.
`PE3-ASBR(config-router)#exit`	Exit the router mode.
`PE3-ASBR(config)#commit`	Commit candidate configuration to be running configuration.
`PE3-ASBR(config)#exit`	Exit the config mode.

P2

`#configure terminal`	Enter configure mode.
`P2(config)#interface lo`	Enter interface mode.
`P2(config-if)# ip address 6.6.6.6/32 secondary`	Assign the IPv4 address.
`P2(config-if)#exit`	Exit interface mode.
`P2(config)#interface xe0`	Enter interface mode.
`P2(config-if)#ip address 21.1.1.5/24`	Assign the IPv4 address.
`P2(config-if)#exit`	Exit interface mode.
`P2(config)#interface xe11`	Enter interface mode.
`P2(config-if)#ip address 22.1.1.5/24`	Assign the IPv4 address.
`P2(config-if)#exit`	Exit interface mode.
`P2(config)#router ospf 1`	Enter router OSPF mode.
`P2(config-router)#ospf router-id 6.6.6.6`	Configure OSPF router id same as loopback ip address.
`P2(config-router)# network 6.6.6.6/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`P2(config-router)#network 21.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`P2(config-router)#network 22.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`P2(config-router)#exit`	Exit router OSPF mode.
`P2(config)#router ldp`	Enter router LDP mode.

P2(config-router)#router-id 6.6.6.6	Set the router ID to IP address 6.6.6.6
P2(config-router)#transport-address ipv4 6.6.6.6	Configure LDP transport address same as loopback address
P2(config-router)#exit	Exit LDP mode.
P2(config)#interface xe0	Enter interface mode.
P2(config-if)#label-switching	Enable label switching in interface.
P2(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xe11	Enter interface mode.
P2(config-if)#label-switching	Enable label switching in interface.
P2(config-if)# enable-ldp ipv4	Enable LDP on the interface.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit candidate configuration to be running configuration.
P2(config)#exit	Exit the config mode.

PE4

#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter interface mode.
PE4(config-if)#ip address 28.28.28.28/32 secondary	Assign the IPv4 address.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#ip vrf vrf1	Create a new VRF named vrf1.
PE4(config-vrf)#rd 1:1	Assign the route distinguisher (RD) value as 1:1.
PE4(config-vrf)#route-target both 1:1	Configure import and export RTs for the VRF.
PE4(config-vrf)#exit	Exit VRF mode.
PE4(config)#interface xe23	Enter interface mode.
PE4(config-if)#ip vrf forwarding vrf1	Bind the interface connected to the CE router with VRF vrf1.
PE4(config-if)#ip address 30.1.1.1/24	Assign the IPv4 address.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#interface xe11	Enter interface mode.
PE4(config-if)#ip address 22.1.1.28/24	Assign the IPv4 address.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#router ospf 1	Enter router OSPF mode.
PE4(config-router)#ospf router-id 28.28.28.28	Configure OSPF router id same as loopback ip address.
PE4(config-router)#network 22.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE4(config-router)#network 28.28.28.28/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
PE4(config-router)#exit	Exit OSPF router mode.
PE4(config)# router ldp	Enter router LDP mode.
PE4(config-router)#router-id 28.28.28.28	Set the router ID to IP address 28.28.28.28

PE4(config-router)#transport-address ipv4 28.28.28.28	Configure LDP transport address same as loopback address
PE4(config-router)#exit	Exit LDP mode.
PE4(config)#interface xe11	Enter interface mode.
PE4(config-if)#label-switching	Enable label switching in interface.
PE4(config-if)# enable-ldp ipv4	Enable LDP on the interface.
PE4(config-if)#exit	Exit interface mode.
PE4(config-if)#router bgp 65001	Enter BGP router mode.
PE4(config-router)# bgp router-id 28.28.28.28	Configure BGP router-id.
PE4(config-router)# no bgp default ipv4-unicast	Configure BGP speaker to have no default ipv4 unicast capability exchange between neighbors.
PE4(config-router)#address-family ipv4 unicast	Enter the IPv4 unicast address family.
PE4(config-router-af)#network 28.28.28.28/32	Advertise loopback address.
PE4(config-router-af)#exit-address-family	Exit address family mode
PE4(config-router)# neighbor 40.40.40.40 remote-as 65001	Configure PE3-ASBR2 as an iBGP peer.
PE4(config-router)# neighbor 40.40.40.40 update-source lo	Update the source as loopback for iBGP peering with the remote PE3-ASBR router.
PE4(config-router)# neighbor 41.41.41.41 remote-as 65000	Configure PE1 as an eBGP peer.
PE4(config-router)# neighbor 41.41.41.41 ebgp-multihop	Configure eBGP multichip for eBGP peer PE1.
PE4(config-router)# neighbor 41.41.41.41 update-source lo	Update the source as loopback for eBGP peering with the remote PE1 router.
PE4(config-router)# allocate-label all	Configure allocate-label.
PE4(config-router)# address-family ipv4 labeled-unicast	Enter address-family ipv4 labeled-unicast.
PE4(config-router-af)# neighbor 40.40.40.40 activate	Activate iBGP neighbor.
PE4(config-router-af)# exit-address-family	Exit address-family ipv4 labeled-unicast.
PE4(config-router)# address-family vpnv4 unicast	Enter address-family vpnv4.
PE4(config-router-af)# neighbor 41.41.41.41 allow-ebgp-vpn	Activate eBGP neighbor PE1.
PE4(config-router-af)# neighbor 41.41.41.41 activate	Configure allow-ebgp-vpn for ebgp neighbor PE1.
PE4(config-router-af)# exit-address-family	Exit address-family vpnv4.
PE4(config-router)# address-family ipv4 vrf vrf1	Enter the IPv4 address family for VRF vrf1.
PE4(config-router-af)# redistribute connected	Redistribute connected route.
PE4(config-router-af)# exit-address-family	Exit IPv4 VRF Address Family mode.
PE4(config-router)#exit	Exit the router mode.

PE4(config)#commit	Commit candidate configuration to be running configuration.
PE4(config)#exit	Exit the config mode.

Validation

PE1

```
PE1#show ip bgp labeled-unicast summary
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 10
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS    MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
2.2.2.2                  4 65000  374        368      10      0      0
02:37:43               3

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop         In Label     Out Label
*>i 5.5.5.5/32       2.2.2.2           24960        24965
*>i 28.28.28.28/32   2.2.2.2           24962        24962
*>i 31.31.31.31/32   2.2.2.2           24963        24961
*>  41.41.41.41/32   0.0.0.0           24961          -

PE1#show ip route  bgp
IP Route Table for VRF "default"
B            28.28.28.28/32 [200/0] via 2.2.2.2 (recursive via 11.1.1.31),
02:41:00

Gateway of last resort is not set

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
   L>    2.2.2.2/32        4       0          Yes   LSP_DEFAULT    24321
xe15        No         11.1.1.31
   L>    5.5.5.5/32        6       0          Yes   LSP_DEFAULT    24324
xe15        No         11.1.1.31
   B     5.5.5.5/32        7       0          Yes   LSP_DEFAULT    24965
-           No         2.2.2.2
   L>    12.1.1.0/24        2       0          Yes   LSP_DEFAULT     3
xe15        No         11.1.1.31
   L>    13.1.1.0/24        3       0          Yes   LSP_DEFAULT     3
xe15        No         11.1.1.31
```

```
   B>    28.28.28.28/32     8       0          Yes   LSP_DEFAULT    24962
-            No        2.2.2.2
   L>    31.31.31.31/32     5       0          Yes   LSP_DEFAULT    24322
xe15         No        11.1.1.31
   B     31.31.31.31/32     9       0          Yes   LSP_DEFAULT    24961
-            No        2.2.2.2
   L>    51.51.51.51/32     1       0          Yes   LSP_DEFAULT    3
xe15         No        11.1.1.31

PE1#show ip bgp vpnv4 all summary
BGP router identifier 41.41.41.41, local AS number 65000
BGP table version is 4
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
28.28.28.28              4 65001  340        338       4      0      0
02:22:11              1

Total number of neighbors 1

Total number of Established sessions 1

PE1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*> l 10.1.1.0/24      0.0.0.0              0         100           32768    ?
*>   30.1.1.0/24      28.28.28.28          0         100           0
65001 ?
 Announced routes count = 1
 Accepted routes count = 1
Route Distinguisher: 1:1
*>   30.1.1.0/24      28.28.28.28          0         100           0
65001 ?
 Announced routes count = 0
 Accepted routes count = 1

PE1#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
C    *>  10.1.1.0/24 is directly connected, xe23, 1d19h57m
B    *>  30.1.1.0/24 [20/0] via 28.28.28.28, 02:22:28

Gateway of last resort is not set
```

P1

```
 P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                        LSP-Type
  L>   2.2.2.2/32       2         24321      3         N/A       xe21
12.1.1.2                 LSP_DEFAULT
  L>   41.41.41.41/32    1         24320      3         N/A       xe15
11.1.1.2                 LSP_DEFAULT
  L>   31.31.31.31/32    4         24323     Nolabel    N/A       N/A
127.0.0.1                LSP_DEFAULT
  L>   31.31.31.31/32    3         24322     Nolabel    N/A       N/A
127.0.0.1                LSP_DEFAULT
  L>   5.5.5.5/32       5         24324     Nolabel    N/A       N/A
127.0.0.1                LSP_DEFAULT
```

PE2-ASBR

```
PE2-ASBR#show ip bgp labeled-unicast summary
BGP router identifier 2.2.2.2, local AS number 65000
BGP table version is 10
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
20.1.1.40                4 65001 6427       6521      10      0      0
1d20h28m              2
41.41.41.41              4 65000  379        385      10      0      0
02:42:38              1

Total number of neighbors 2

Total number of Established sessions 2

PE2-ASBR#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                        LSP-Type
  B>   31.31.31.31/32    2         24961     Nolabel    N/A       N/A
127.0.0.1                LSP_DEFAULT
  B>   41.41.41.41/32    1         24960     24961     N/A       N/A
41.41.41.41              LSP_DEFAULT
  B>   5.5.5.5/32       6         24965     24965     N/A       N/A
20.1.1.40                LSP_DEFAULT
  B>   28.28.28.28/32    3         24962     24961     N/A       N/A
20.1.1.40                LSP_DEFAULT
```

```
PE2-ASBR#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
   B>    5.5.5.5/32         8       0          Yes   LSP_DEFAULT    24965
xe5        No        20.1.1.40
   L>    11.1.1.0/24        1       0          Yes   LSP_DEFAULT    3
xe20        No        12.1.1.31
   L>    13.1.1.0/24        2       0          Yes   LSP_DEFAULT    3
xe20        No        12.1.1.31
   B>    28.28.28.28/32     7       0          Yes   LSP_DEFAULT    24961
xe5        No        20.1.1.40
   L>    31.31.31.31/32     5       0          Yes   LSP_DEFAULT    24323
xe20        No        12.1.1.31
   L>    41.41.41.41/32     3       0          Yes   LSP_DEFAULT    24320
xe20        No        12.1.1.31
   B     41.41.41.41/32     6       0          Yes   LSP_DEFAULT    24961
-           No        41.41.41.41
   L>    51.51.51.51/32     4       0          Yes   LSP_DEFAULT    3
xe20        No        12.1.1.31

PE2-ASBR#show ip route  bgp
IP Route Table for VRF "default"
B            28.28.28.28/32 [20/0] via 20.1.1.40, xe5, 02:41:38

Gateway of last resort is not set
```

PE3-ASBR

```
PE3-ASBR#show ip bgp labeled-unicast summary
BGP router identifier 40.40.40.40, local AS number 65001
BGP table version is 11
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS    MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
20.1.1.2                 4 65000 6263       6267      11      0      0
1d20h31m              2
28.28.28.28              4 65001  383        389      11      0      0
02:42:56              1

Total number of neighbors 2

Total number of Established sessions 2

PE3-ASBR#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                      LSP-Type
```

```
  B>  31.31.31.31/32    6         24964     24961     N/A      N/A
20.1.1.2                  LSP_DEFAULT
  B>  41.41.41.41/32    2         24960     24960     N/A      N/A
20.1.1.2                  LSP_DEFAULT
  B>  28.28.28.28/32    3         24961     24321     N/A      N/A
28.28.28.28               LSP_DEFAULT
  B>  5.5.5.5/32       7         24965     Nolabel   N/A      N/A
127.0.0.1                 LSP_DEFAULT

PE3-ASBR#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                  FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
  L>    5.5.5.5/32         5       0          Yes   LSP_DEFAULT    24320
xe1        No         21.1.1.5
  L>    6.6.6.6/32         6       0          Yes   LSP_DEFAULT    3
xe1        No         21.1.1.5
  L>    22.1.1.0/24        7       0          Yes   LSP_DEFAULT    3
xe1        No         21.1.1.5
  L>    23.1.1.0/24        8       0          Yes   LSP_DEFAULT    3
xe1        No         21.1.1.5
  L>    28.28.28.28/32     9       0          Yes   LSP_DEFAULT    24321
xe1        No         21.1.1.5
  B     28.28.28.28/32     2       0          Yes   LSP_DEFAULT    24321
-          No         28.28.28.28
  B>    31.31.31.31/32     4       0          Yes   LSP_DEFAULT    24961
xe5        No         20.1.1.2
  B>    41.41.41.41/32     1       0          Yes   LSP_DEFAULT    24960
xe5        No         20.1.1.2


PE3-ASBR#show ip route  bgp
IP Route Table for VRF "default"
B            41.41.41.41/32 [20/0] via 20.1.1.2, xe5, 02:45:37

Gateway of last resort is not set
```

P2

```
 P2#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                        LSP-Type
  L>   5.5.5.5/32       3         24322     Nolabel    N/A      N/A
127.0.0.1                 LSP_DEFAULT
  L>   5.5.5.5/32       1         24320     Nolabel    N/A      N/A
127.0.0.1                 LSP_DEFAULT
  L>   28.28.28.28/32    2         24321      3         N/A      xe11
22.1.1.28                 LSP_DEFAULT
  L>   31.31.31.31/32    4         24323     Nolabel    N/A      N/A
127.0.0.1                 LSP_DEFAULT
```

```
  L>  40.40.40.40/32    5         24324      3         N/A       xe0
21.1.1.40               LSP_DEFAULT
```

PE4

```
 PE4#show ip bgp labeled-unicast summary
BGP router identifier 28.28.28.28, local AS number 65001
BGP table version is 12
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
40.40.40.40             4 65001  404        399      12      0      0
02:49:41             3

Total number of neighbors 1

Total number of Established sessions 1

PE4#show ip bgp labeled-unicast

Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, S - stale
     Network          Next Hop        In Label     Out Label
*>i 5.5.5.5/32       40.40.40.40       24324        24965
*>  28.28.28.28/32   0.0.0.0           24321          -
*>i 31.31.31.31/32   40.40.40.40       24322        24964
*>i 41.41.41.41/32   40.40.40.40       24323        24960
PE4#

PE4#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf   ELC       Nexthop
  L>    5.5.5.5/32        4       0          Yes   LSP_DEFAULT    24322
xe11        No        22.1.1.5
  B     5.5.5.5/32        3       0          Yes   LSP_DEFAULT    24965
-           No        40.40.40.40
  L>    6.6.6.6/32        5       0          Yes   LSP_DEFAULT    3
xe11        No        22.1.1.5
  L>    21.1.1.0/24       6       0          Yes   LSP_DEFAULT    3
xe11        No        22.1.1.5
  L>    23.1.1.0/24       7       0          Yes   LSP_DEFAULT    3
xe11        No        22.1.1.5
  L>    31.31.31.31/32    8       0          Yes   LSP_DEFAULT    24323
xe11        No        22.1.1.5
  B     31.31.31.31/32    1       0          Yes   LSP_DEFAULT    24964
-           No        40.40.40.40
  L>    40.40.40.40/32    9       0          Yes   LSP_DEFAULT    24324
xe11        No        22.1.1.5
  B>    41.41.41.41/32    2       0          Yes   LSP_DEFAULT    24960
-           No        40.40.40.40

PE4#show ip bgp vpnv4 all summary
BGP router identifier 28.28.28.28, local AS number 65001
```

```
BGP table version is 4
2 BGP AS-PATH entries
0 BGP community entries

Neighbor                 V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/
Down   State/PfxRcd
41.41.41.41              4 65000  373        376       4      0      0
02:37:04               1

Total number of neighbors 1

Total number of Established sessions 1

PE4#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop           Metric    LocPrf      Weight Path
Route Distinguisher: 1:1 (Default for VRF vrf1)
*>   10.1.1.0/24      41.41.41.41         0         100           0
65000 ?
*> l 30.1.1.0/24      0.0.0.0             0         100           32768    ?
 Announced routes count = 1
 Accepted routes count = 1
Route Distinguisher: 1:1
*>   10.1.1.0/24      41.41.41.41         0         100           0
65000 ?
 Announced routes count = 0
 Accepted routes count = 1

PE4#show ip route vrf vrf1 database
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       > - selected route, * - FIB route, p - stale info

IP Route Table for VRF "vrf1"
B    *>  10.1.1.0/24 [20/0] via 41.41.41.41, 02:37:23
C    *>  30.1.1.0/24 is directly connected, xe21, 1d20h11m

Gateway of last resort is not set

PE4#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, S - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                  LSP-Type
```

```
   B>   41.41.41.41/32    4         24323      24960      N/A       N/A
40.40.40.40                 LSP_DEFAULT
   B>   28.28.28.28/32    2         24321      Nolabel    N/A       N/A
127.0.0.1                   LSP_DEFAULT
   B>   vrf1            1         24320      Nolabel    N/A       vrf1
N/A                         LSP_DEFAULT
   B>   31.31.31.31/32    3         24322      24964      N/A       N/A
40.40.40.40                 LSP_DEFAULT
   B>   5.5.5.5/32       5         24324      24965      N/A       N/A
40.40.40.40                 LSP_DEFAULT
```

CHAPTER 15 MPLS Service Mapping Configuration

This chapter includes step-by-step configurations for tunnel policy configuration for all the MPLS services.

Overview

This feature enables MPLS services L2VPN, L3VPN, EVPN traffic steering with SR-policy as the underlying transport using local-tunnel-policy configuration. This is achieved with the help of color coding and association between service and MPLS transport.

A local-tunnel-policy is created which specifies the color of the transport-tunnel in order to be selected for a VPN service. The created tunnel-policy is now applied for the VPN service so that it will select the preferred tunnel. The destination address of the preferred tunnel identifies a peer PE so the PE will forward traffic destined for that peer PE over the preferred tunnel. If you specify multiple preferred tunnels that have the same destination address in a tunnel policy, only the first configured tunnel takes effect and if the first tunnel is not available, the second tunnel is used, and so forth. No load balancing will be performed on these tunnels.

The tunnels selected by 2 methods, dedicated and best-effort. By default, tunnel policy uses dedicated method. If you configure dedicated method for a tunnel policy, the tunnel policy uses the preferred tunnel to forward traffic destined for the peer PE. If not, the MPLS VPN service will be down. If you configure best-effort method for a tunnel policy, the tunnel policy uses the preferred tunnel to forward traffic destined for the peer PE. If not, the MPLS VPN selects the available MPLS transport in MPLS forwarding table.

Topology

The diagram depicts the topology for the configuration examples that follow.

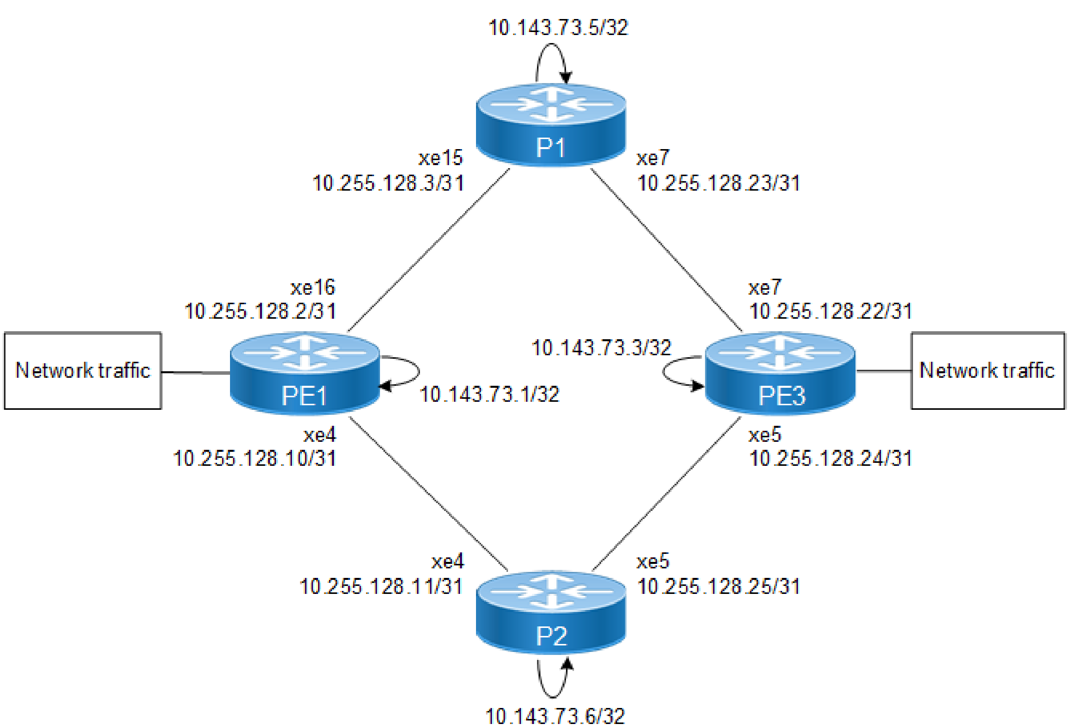

Figure 15-6: Service mapping to Tunnel

Configuration

Below are the sample configuration for EVPN (E-LINE, E-LAN), L3VPN, 6VPE, VPWS, and VPLS services with Tunnel Policy along with SR as transport.

PE1: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 10.143.73.1/32 secondary`	Configure IP address on loopback interface.
`(config-if)#prefix-sid index 1`	Configure prefix sid index value
`(config-if)#exit`	Exit interface mode

PE1: Global EVPN MPLS Command:

`#configure terminal`	Enter configuration mode.
`(config)#evpn mpls enable`	Enable EVPN MPLS. Note: Reload is required after Enabling/ Disabling EVPN MPLS Feature.
`(config)#evpn mpls vtep-ip-global 10.143.73.1`	Configuring loopback IP as VTEP global IP
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#end`	Ending config mode
`#write memory`	Save config to startup config
`#reload`	Reload device after enabling evpn

PE1: LDP Configuration

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 10.143.73.1`	Set the router ID to IP address 10.143.73.1.
`(config-router)#transport-address ipv4 10.143.73.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
`(config-router)# targeted-peer ipv4 10.143.73.3`	Configure targeted peer
`(config-router-targeted-peer)# exit-targeted-peer-mode`	Exit from router target peer and LDP mode

PE1: Interface Configuration Network Side

`(config)#interface xe16`	Enter the Interface mode for xe16
`(config-if)# ip address 10.255.128.2/31`	Configure IP address on the interface.
`(config-if)#mtu 9900`	Configure mtu at interface level
`(config-if)# label-switching`	Enable label switching on the interface.
`(config-if)# enable-ldp ipv4`	Enable ldp on the interface.
`(config-if)#exit`	Exit interface mode

(config)#interface xe4	Enter the Interface mode for xe4.
(config-if)# ip address 10.255.128.10/31	Configure IP address on the interface.
(config-if)#mtu 9900	Configure mtu at interface level
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# enable-ldp ipv4	Enable ldp on the interface.
(config-if)#exit	Exit interface mode

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.1	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.255.128.2/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.10/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE1: BGP Configuration

(config)# router bgp 100	Enter the Router BGP mode, ASN: 100.
(config-router)# neighbor 10.143.73.3 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback ip.
(config-router)# neighbor 10.143.73.3 fall-over bfd multihop	Configure neighbor bfd multihop
(config-router)# neighbor 10.143.73.3 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 10.143.73.3 advertisement-interval 0	Configure advertisement interval
(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling VPNv4 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn vpls	Enter l2vpn Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling l2vpn Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn evpn	Enter evpn Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling evpn Address family for neighbor..

(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family vpnv6 unicast	Enter VPNv6 Address family mode
(config-router-af)# neighbor 10.143.73.3 activate	Enabling VPNv6 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.

PE1: SR policy Configuration

(config)#segment-routing	Enter the segment routing mode.
(config-sr)# mpls sr-prefer	prefer segment routing MPLS entries for forwarding.
((config-sr)#traffic-engineering	Enter traffic engineering mode.
(config-sr-te)# policy PE1-P1-PE3	Configure SR policy
(config-sr-pol)# color 1 end-point 10.143.73.3	Configure color with destination address.
(config-sr-pol)#candidate-path 1	Enter candidate path mode.
(config-sr-pol-cp)#dynamic-path ospf 100	Configure dynamic path ospf
(config-sr-pol-cp)#constraints	Enter constraint mode
(config-sr-dyn-cp-cons)# 10.143.73.5 loose	Configure P1 as next-hop loose mode.
(config-sr-dyn-cp-cons)#exit-pol-cp	Exit candidate path mode.
(config-sr-pol-cp)#exit-sr-pol	Exit SR policy mode.
(config-sr-te)# policy PE1-P2-PE3	Configure SR policy
(config-sr-pol)# color 2 end-point 10.143.73.3	Configure color with destination address.
(config-sr-pol)#candidate-path 1	Enter candidate path mode.
(config-sr-pol-cp)#dynamic-path ospf 100	Configure dynamic path ospf
(config-sr-pol-cp)#constraints	Enter constraint mode
(config-sr-dyn-cp-cons)# 10.143.73.6 loose	Configure P2 as next-hop loose mode.
(config-sr-dyn-cp-cons)#exit-pol-cp	Exit candidate path mode.
(config-sr-pol-cp)#exit-sr-pol	Exit SR policy mode.

PE1: Tunnel Policy Configuration

(config)# tunnel-policy PE1-P1-PE3	Configure tunnel policy
(config-tnl-policy)#color 1	Map the color with the SR policy to be used..
(config-tnl-policy)#exit	Exiting tunnel policy mode
(config)# tunnel-policy PE1-P2-PE3	Configure tunnel policy
(config-tnl-policy)#color 2	Map the color with the SR policy to be used..
(config-tnl-policy)#exit	Exiting tunnel policy mode

PE1: VPWS Configuration

`(config)# mpls l2-circuit pe1-to-pe3 2002 10.143.73.3`	Configure the VC for PE3. In this example, pe1-to-pe3 is the VC name, 2002 is the VC ID, and 10.143.73.3 is the VC endpoint IP address.
`(config-pseudowire)# tunnel-select-policy PE1-P1-PE3`	Configure Tunnel-Policy on VC pe1-to-pe3
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#exit`	Exiting from config mode
`(config)#service-template pe1-to-pe3`	Template configuration.
`(config-svc)# match outer-vlan 2002`	Match criteria under template configuration
`(config)#exit`	Exiting from config mode

PE1: VPLS Configuration

`(config)# mpls vpls vpls-pe1-to-pe3pe4-1 2502`	Enter VPLS config mode
`(config-vpls)#signaling ldp`	Define Signaling as LDP
`(config-vpls-sig)#vpls-type ethernet`	Type ethernet configuration for VPLS
`(config-vpls-sig)# vpls-peer 10.143.73.3 tunnel-select-policy PE1-P2-PE3`	Configure VPLS Peer with tunnel-policy
`(config-vpls-sig)#exit-signaling`	Exit Signaling LDP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#service-template vpls-pe1-to-pe3pe4-1`	Template configuration.
`(config-svc)# match outer-vlan 2502`	Match criteria under template configuration
`(config-svc)# rewrite ingress translate 2600 outgoing-tpid dot1.q`	Action performed for service template.
`(config)# mpls vpls vpls-pe1-to-pe3pe4-2 2503`	Enter VPLS config mode
`(config-vpls)#signaling bgp`	Enter the Signaling bgp mode for BGP VPLS.
`(config-vpls-sig)# ve-id 3`	Configure VE ID, which is mandatory for BGP VPLS, otherwise, signaling does not take place. VE ID should be unique per VPLS instance
`(config-vpls-sig)# tunnel-select-policy PE1-P1-PE3`	Configure tunnel-policy for a VPLS instance
`(config-vpls-sig)#exit-signaling`	Exit Signaling LDP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#service-template vpls-pe1-to-pe3pe4-2`	Template configuration.
`(config-svc)# match double-tag outer-vlan 2503 inner-vlan 2504`	Match criteria under template configuration
`(config-svc)# rewrite ingress push 2505`	Action performed for service template.

PE1: MAC VRF and IP VRF Configuration for EVPN and L3VPN services

Note: For EVPN Service, Tunnel Policy can be applied at mac vrf level and VNID level, When Configured at both levels, Preference is given to VNID level.

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)# tunnel-select-policy PE1-P1-PE3	Map tunnel policy to mac vrf
(config-vrf)#rd 10.143.73.1:2	Configuring Route-Distinguisher value 10.143.73.1:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode.
(config)#mac vrf elan500	Enter VRF mode
(config-vrf)#rd 10.143.73.1:500	Configuring Route-Distinguisher value 10.143.73.1:500
(config-vrf)#route-target both 500:500	Configuring import and export value as 500:500
(config)# ip vrf vrf600	Enter VRF mode
(config-vrf)# tunnel-select-policy PE1-P1-PE3	Configure tunnel-policy to be used for the VRF.
(config-vrf)# rd 10.143.73.1:600	Configuring Route-Distinguisher value 10.143.73.1:600
(config-vrf)#route-target both 600:600	Configuring import and export value as 600:600
(config-vrf)#exit	Exiting VRF Mode.

PE1: EVPN and MAC-VRF mapping for ELAN and ELINE

(config)#evpn mpls id 2 xconnect target-mpls-id 252	Configure the EVPN-ELINE identifier with source identifier 2 and target identifier 252.
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier.
(config-evpn-mpls)#exit	Exiting from evpn-mpls mode
(config)# evpn mpls id 500	Configure evpn mpls id 500
(config-evpn-mpls)#tunnel-select-policy PE1-P2-PE3	Map tunnel-policy to EVI
(config-evpn-mpls)#host-reachability-protocol evpn-bgp elan500	Mapping vrf " elan500" to EVPN-VPLS identifier.

PE1: Access side Configuration

(config)#interface xe8	Enter the Interface mode for xe8
(config-if)# switchport	Configure interface as switch port
(config-if)# mpls-l2-circuit pe1-to-pe3 service-template pe1-to-pe3 primary	Bind the interface to the VC with service template
(config-if)# mpls-vpls vpls-pe1-to-pe3pe4-1 service-template vpls-pe1-to-pe3pe4-1	Bind the VPLS instance to the interface
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# mpls-vpls vpls-pe1-to-pe3pe4-2 service-template vpls-pe1-to-pe3pe4-2	Bind the VPLS instance to the interface
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# exit	Exit from the interface
(config)#interface xe8.2 switchport	Configure Interface xe8.2 as switchport

(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 2	Map vpn-id 2 to interface xe8.2 (VPWS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe8.500 switchport	Configure Interface xe8.500 as switchport
(config-if)#encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 500	Map vpn-id 500 to interface xe8.500 (VPLS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe8.600	Enter Interface mode xe8.600
(config-if)# ip vrf forwarding vrf600	Bind the VRF instance to the interface
(config-if)# ip address 170.1.1.1/24	Configure IP address
(config-if)# ipv6 address 1111::1/64	Configure ipv6 address
(config-if)#encapsulation dot1q 600	Setting Encapsulation to dot1q with VLAN ID 600
(config-if)#exit	Exiting interface Mode.
(config)# router bgp 100	Enter BGP router mode
(config-router)#address-family ipv4 vrf vrf600	Configure VRF address family
(config-router-af)redistribute connected	Redistribute connected router
(config-router-af)#neighbor 170.1.1.2 remote-as 200	Configure neighbor with remote-as
(config-router-af)#neighbor 170.1.1.2 activate	Activate the VPN neighbour
(config-router-af)exit-address-family	Exit VRF address family
(config-router)#address-family ipv6 vrf vrf600	Configure ipv6 VRF address family
(config-router-af)redistribute connected	Redistribute connected router
(config-router-af)#neighbor 1111::2 remote-as 200	Configure neighbor with remote-as
(config-router-af)#neighbor 1111::2 activate	Activate the VPN neighbour
(config-router-af)exit-address-family	Exit VRF address family
(config-router-af)exit	End
(config-router)#commit	Commit the candidate configuration to the running configuration

P1: Loopback Interface

(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.5/32 secondary	Configure IP address on loopback interface.
(config-if)#prefix-sid index 5	Configure prefix sid index value
(config-if)#exit	Exit interface mode

P1: Interface Configuration Network Side

(config)#interface xe15	Enter the Interface mode for xe15
(config-if)# ip address 10.255.128.3/31	Configure IP address on the interface.
(config-if)# mtu 9900	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe7	Enter the Interface mode for xe7.
(config-if)# ip address 10.255.128.23/31	Configure IP address on the interface.
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.5	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.5/32 area	
0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.2/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.22/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the candidate configuration to the running configuration

P2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 10.143.73.6/32 secondary	Configure IP address on loopback interface.
(config-if)#prefix-sid index 6	Configure prefix sid index value
(config-if)#exit	Exit interface mode

P2: Interface Configuration Network Side

(config)#interface xe4	Enter the Interface mode for xe4
(config-if)# ip address 10.255.128.11/31	Configure IP address on the interface.
(config-if)# mtu 9900	Configure mtu

(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter the Interface mode for xe5.
(config-if)# ip address 10.255.128.25/31	Configure IP address on the interface.
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.6	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.6/32 area	
0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.10/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the candidate configuration to the running configuration

PE3: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 10.143.73.3/32 secondary	Configure IP address on loopback interface.
(config-if)#prefix-sid index 3	Configure prefix sid index value
(config-if)#exit	Exit interface mode

PE3: Global EVPN MPLS Command

#configure terminal	Enter configuration mode.
(config)#evpn mpls enable	Enable EVPN MPLS. Note: Reload is required after Enabling/ Disabling EVPN MPLS Feature.
(config)#evpn mpls vtep-ip-global 10.143.73.3	Configuring vtep global ip to loopback IP.
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	End configuration mode

#write memory	Saving configs to startup config
#reload	Reload device after enabling evpn

PE3: LDP Configuration

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 10.143.73.3	Set the router ID to IP address 10.143.73.3.
(config-router)#transport-address ipv4 10.143.73.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)# targeted-peer ipv4 10.143.73.1	Configure targeted peer
(config-router-targeted-peer)# exit-targeted-peer-mode	Exit from router target peer and LDP mode

PE3: Interface Configuration Network Side

(config)#interface xe5	Enter the Interface mode for xe5
(config-if)# ip address 10.255.128.24/31	Configure IP address on the interface.
(config-if)#mtu 9900	Configure mtu at interface level
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# enable-ldp ipv4	Enable ldp on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe7	Enter the Interface mode for xe7.
(config-if)# ip address 10.255.128.22/31	Configure IP address on the interface.
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# enable-ldp ipv4	Enable ldp on the interface.
(config-if)#exit	Exit interface mode

PE3: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 10.143.73.3	Router-id configurations
(config-router)# bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)# network 10.143.73.3/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.255.128.22/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 10.255.128.24/31 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 17000	Enable SRGB under ospf process 100
(config-router)#segment-routing mpls	Enable segment routing
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE3: BGP Configuration

(config)# router bgp 100	Enter the Router BGP mode, ASN: 100.
(config-router)# neighbor 10.143.73.1 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback ip.
(config-router)# neighbor 10.143.73.1 fall-over bfd multihop	Configure neighbor bfd multihop
(config-router)# neighbor 10.143.73.1 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 10.143.73.1 advertisement-interval 0	Configure advertisement interval
(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling VPNv4 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn vpls	Enter l2vpn Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling l2vpn Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family l2vpn evpn	Enter evpn Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling evpn Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.
(config-router)# address-family vpnv6 unicast	Enter VPNv6 Address family mode
(config-router-af)# neighbor 10.143.73.1 activate	Enabling VPNv6 Address family for neighbor..
(config-router-af)# exit-address-family	Exit Address-family mode.

PE3: VPWS Configuration

(config)# mpls l2-circuit pe3-to-pe1 2002 10.143.73.1	Configure the VC for PE-1. In this example, pe3-to-pe1 is the VC name, 2002 is the VC ID, and 10.143.73.1 is the VC endpoint IP address.
(config)#exit	Exiting from config mode
(config)#service-template pe3-to-pe1	Template configuration.
(config-svc)# match outer-vlan 2002	Match criteria under template configuration
(config)#exit	Exiting from config mode

PE3: VPLS Configuration

(config)# mpls vpls vpls-pe3-to-pe1pe4-1 2502	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type Ethernet	Type ethernet configuration for VPLS
(config-vpls-sig)# vpls-peer 10.143.73.1	Configure VPLS Peer

(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls-pe3-to-pe1pe4-1	Template configuration.
(config-svc)# match outer-vlan 2502	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2600 outgoing-tpid dot1.q	Action performed for service template.
(config)# mpls vpls vpls-pe3-to-pe1pe4-2 2503	Enter VPLS config mode
(config-vpls)#signaling bgp	Enter the Signaling bgp mode for BGP VPLS.
(config-vpls-sig)# ve-id 4	Configure VE ID, which is mandatory for BGP VPLS, otherwise, signaling does not take place. VE ID should be unique per VPLS instance
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls-pe3-to-pe1pe4-2	Template configuration.
(config-svc)# match double-tag outer-vlan 2503 inner-vlan 2504	Match criteria under template configuration
(config-svc)# rewrite ingress push 2505	Action performed for service template.

PE3: MAC and IP VRF Configuration

(config)#mac vrf vrf2	Enter VRF mode
(config-vrf)#rd 10.143.73.3:2	Configuring Route-Distinguisher value 10.143.73.3:2
(config-vrf)#route-target both 2:2	Configuring import and export value as 2:2
(config-vrf)#exit	Exiting VRF Mode.
(config)#mac vrf elan500	Enter VRF mode
(config-vrf)#rd 10.143.73.3:500	Configuring Route-Distinguisher value 10.143.73.3:500
(config-vrf)#route-target both 500:500	Configuring import and export value as 500:500
(config)# ip vrf vrf600	Enter VRF mode
(config-vrf)# rd 10.143.73.3:600	Configuring Route-Distinguisher value 10.143.73.3:600
(config-vrf)#route-target both 600:600	Configuring import and export value as 600:600
(config-vrf)#exit	Exiting VRF Mode.

PE3: EVPN and mac vrf mapping Configuration

(config)#evpn mpls id 252 xconnect target-mpls-id 2	Configure the EVPN-ELINE identifier with source identifier 252 and target identifier 2.
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf2	Mapping vrf "vrf2" to EVPN-VPWS identifier.
(config-evpn-mpls)#exit	Exiting from evpn-mpls mode
(config)# evpn mpls id 500	Configure evpn mpls id 500
(config-evpn-mpls)#host-reachability-protocol evpn-bgp elan500	Mapping vrf " elan500" to EVPN-VPLS identifier.

PE3: Access side Configuration

(config)#interface xe4	Enter the Interface mode for xe8
(config-if)# switchport	Configure interface as switch port
(config-if)# mpls-l2-circuit pe3-to-pe1 service-template pe3-to-pe1 primary	Bind the VPWS instance to the interface
(config-if)# mpls-vpls vpls-pe3-to-pe1pe4-1 service-template vpls-pe3-to-pe1pe4-1	Bind the VPLS instance to the interface
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# mpls-vpls vpls-pe3-to-pe1pe4-2 service-template vpls-pe3-to-pe1pe4-2	Bind the VPLS instance to the interface
(config-if-vpls)# exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)# exit	Exit from the interface
(config)#interface xe4.2 switchport	Configure Interface xe4.2 as switchport
(config-if)#encapsulation dot1q 2	Setting Encapsulation to dot1q with VLAN ID 2
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 252	Map vpn-id 252 to interface xe4.2 (VPWS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe4.500 switchport	Configure Interface xe4.500 as switchport
(config-if)#encapsulation dot1q 500	Setting Encapsulation to dot1q with VLAN ID 500
(config-if)#access-if-evpn	Entering Access mode for EVPN MPLS ID configuration.
(config-access-if)#map vpn-id 500	Map vpn-id 500 to interface xe4.500 (VPLS).
(config-access-if)#exit	Exiting out of access interface mode.
(config)#interface xe4.600	Enter Interface mode xe4.600
(config-if)# ip vrf forwarding vrf600	Bind the VRF instance to the interface
(config-if)# ip address 180.1.1.1/24	Configure IP address
(config-if)# ipv6 address 2222::1/64	Configure ipv6 address
(config-if)#encapsulation dot1q 600	Setting Encapsulation to dot1q with VLAN ID 600
(config-if)#exit	Exiting interface Mode.
(config)# router bgp 100	Enter BGP router mode
(config-router)#address-family ipv4 vrf vrf600	Configure VRF address family
(config-router-af)redistribute connected	Redistribute connected router
(config-router-af)#neighbor 180.1.1.2 remote-as 300	Configure neighbor with remote-as
(config-router-af)#neighbor 180.1.1.2 activate	Activate the VPN neighbour
(config-router-af)exit-address-family	Exit VRF address family
(config-router)#address-family ipv6 vrf vrf600	Configure ipv6 VRF address family
(config-router-af)redistribute connected	Redistribute connected router
(config-router-af)#neighbor 2222::2 remote-as 300	Configure neighbor with remote-as
(config-router-af)#neighbor 2222::2 activate	Activate the VPN neighbour

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(config-router-af)exit-address-family	Exit VRF address family
(config-router-af)end	End
(config)#commit	Commit the candidate configuration to the running configuration

Validation

CLI's : Show segment-routing policy, show tunnel-policy, show tunnel-policy service details, show mpls forwarding-table

PE1

```
PE1#show segment-routing policy

Policy-Name     Color       End-point        State       Forwarding-Info
PE1-P1-PE3        1           10.143.73.3      UP          3/16003/xe16
PE1-P2-PE3        2           10.143.73.3      UP          3/16003/xe4
```

VPWS

```
PE1#show mpls vc-table
VC-ID   Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop         Status
2002     N/A      N/A            xe8           xe16          25600      3             10.143.73.3     Active

PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: pe1-to-pe3, id: 2002  PW-INDEX: 2 service-tpid: dot1.q
 Tunnel-Policy: PE1-P1-PE3 >>> VPWS is up by using Applied Tunnel Policy
 Endpoint: 10.143.73.3
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe8
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : pe1-to-pe3
  Match criteria : 2002
```

VPLS

```
PE1#show mpls vpls mesh
VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St   PW-INDEX SIG-Protocol  Status
2502       10.143.73.3       3             26241      xe4            25601      2/Up      1         LDP           Active
2503       10.143.73.3       3             25604      xe16           24962      2/Up      3         BGP           Active

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: vpls-pe1-to-pe3pe4-1, ID: 2502
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe8
 Service-template : vpls-pe1-to-pe3pe4-1
  Match criteria : 2502
  Action type : Translate
  Action value : 2600
  Outgoing tpid : dot1.q

 Mesh Peers:
   10.143.73.3 (Up)
   Tunnel-Policy: PE1-P2-PE3 >>> VPLS-LDP is up using applied tunnel policy
```

```
Virtual Private LAN Service Instance: vpls-pe1-to-pe3pe4-2, ID: 2503
 SIG-Protocol: BGP
  Route-Distinguisher :100:2503
  Route-Target :100:2503
  VE-ID :3
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe8
 Service-template : vpls-pe1-to-pe3pe4-2
  Match criteria : 2503/2504
  Action type : Push
  Action value : 2505

 Mesh Peers:
   10.143.73.3 (Up)
   Tunnel-Policy: PE1-P1-PE3 VPLS-BGP is up using applied tunnel policy
```

EVPN E-LAN

```
PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
Destination     Status     evpn-id  Policy         Network-Intf Tunnel-Label MC-
    Local            Remote
Label UC-Label MC-Label UC-Label
===================================================================================
10.143.73.3     Installed  500      PE1-P2-PE3     xe4          3            640      17       640      --
Total number of entries are 1

Here Tunnel Policy is applied under VNID level.
```

EVPN E-LINE

```
PE1#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
 (*) in Policy - tunnel-policy inherited from mac-vrf
                             Local    Remote
 Destination     Status     VPWS-ID  VPWS-ID  Policy         Network-Intf Tunnel-
   Local          Remote
Label MC-Label UC-Label MC-Label UC-Label
=========================================================================================================================
 10.143.73.3     Installed  2        252      PE1-P1-PE3(*)  xe16         3            --       16       --       16

Total number of entries are 1

Here Tunnel Policy is applied under mac-vrf level.
```

L3VPN and 6VPE

```
PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 4
 Primary FTN entry with FEC: 180.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: PE1-P1-PE3
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 1
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 8
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: BGP, Stale: NO, BGP out intf: xe16, transport out intf: xe16, out label: 25024
    Nexthop addr: 10.143.73.3        cross connect ix: 6, op code: Push and Lookup


Output for IPv6 VRF table with id: 4
 Primary FTN entry with FEC: 2222::/64, id: 13, row status: Active, Tunnel-Policy: PE1-P1-PE3
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 1
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 8
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
      Out-segment with ix: 8, owner: BGP, Stale: NO, BGP out intf: xe16, transport out intf: xe16, out label: 25024
    Nexthop addr: 10.143.73.3        cross connect ix: 6, op code: Push and Lookup

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label    Out-Intf    ELC   Nexthop
   P>   10.143.73.3/32      4         10        1           Yes   LSP_DEFAULT  3            xe16        No    10.255.128.3
   P>   10.143.73.3/32      5         11        2           Yes   LSP_DEFAULT  3            xe4         No    10.255.128.11
   O    10.143.73.3/32      1         3         0           Yes   LSP_DEFAULT  16003        xe16        No    10.255.128.3
   O>   10.143.73.5/32      2         5         0           Yes   LSP_DEFAULT  3            xe16        No    10.255.128.3
   O>   10.143.73.6/32      3         6         0           Yes   LSP_DEFAULT  3            xe4         No    10.255.128.11

PE1#show mpls forwarding-table detail
FEC prefix: 10.143.73.3/32, FTN-ID: 4
  Owner: SR_POLICY, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: 1, Color: 1
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 10
  Out-Label: 3, Out-Intf: xe16, Nexthop: 10.255.128.3
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No

FEC prefix: 10.143.73.3/32, FTN-ID: 5
  Owner: SR_POLICY, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: 2, Color: 2
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 11
  Out-Label: 3, Out-Intf: xe4, Nexthop: 10.255.128.11
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No

FEC prefix: 10.143.73.3/32, FTN-ID: 1
  Owner: OSPF-SR, FTN type: Regular, State: Not Selected
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 3
  Out-Label: 16003, Out-Intf: xe16, Nexthop: 10.255.128.3
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No

FEC prefix: 10.143.73.5/32, FTN-ID: 2
  Owner: OSPF-SR, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 5
  Out-Label: 3, Out-Intf: xe16, Nexthop: 10.255.128.3
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No

FEC prefix: 10.143.73.6/32, FTN-ID: 3
  Owner: OSPF-SR, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 6
  Out-Label: 3, Out-Intf: xe4, Nexthop: 10.255.128.11
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No
```

Tunnel policy Output after applying under all services

```
PE1#show tunnel-policy
tunnel-policy PE1-P1-PE3
  color 1
  tunnel-mode dedicated
  tunnel-type any
Total Services attached:
  VRF     : 1
  VPWS    : 1
```

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```
  VPLS    : 1
  EVPN    : 1

tunnel-policy PE1-P2-PE3
  color 2
  tunnel-mode dedicated
  tunnel-type any
Total Services attached:
  VRF     : 0
  VPWS    : 0
  VPLS    : 1
  EVPN : 1

PE1#show tunnel-policy service details
List of services configured with tunnel-policy PE1-P1-PE3:
  VPWS
   VPWS-Id: 2002, Name: pe1-to-pe3 Status: UP, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
  L3VPN
   VRF id 4
    FTN id: 1, Prefix: 180.1.1.0/24, Status: Up, Label: 25024, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
    FTN id: 13, Prefix: 2222::/64, Status: Up, Label: 25024, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
  VPLS
   VPLS-Id: 2503, Name: vpls-pe1-to-pe3pe4-2, Status: UP, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
  EVPN
   EVPN-Id: 2, Tunnel count: 1
    Peer: 10.143.73.3, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 1
List of services configured with tunnel-policy PE1-P2-PE3:
  VPLS
   VPLS-Id: 2502, Name: vpls-pe1-to-pe3pe4-1, Status: UP, Mapped Tunnel: SR_POLICY, ftn_ix 5, color 2
  EVPN
   EVPN-Id: 500, Tunnel count: 1
    Peer: 10.143.73.3, Mapped Tunnel: SR_POLICY, ftn_ix 5, color 2
```

PE2 Validation:

```
PE2#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP


VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
2002 N/A N/A xe22 xe7 26880 16001 10.143.73.1 Active


PE2#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: pe3-to-pe1, id: 2002 PW-INDEX: 2 service-tpid: dot1.q
Endpoint: 10.143.73.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe4
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : pe3-to-pe1
Match criteria : 2002


PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP


VPLS-ID Peer Addr Tunnel-Label In-Label Network-Intf Out-Label Lkps/St PW-INDEX SIG-Protocol Status
2502 10.143.73.1 16001 26881 xe7 26881 2/Up 1 LDP Active
2503 10.143.73.1 16001 25602 xe7 25603 2/Up 3 BGP Active

PE2#show mpls vpls detail
Virtual Private LAN Service Instance: vpls-pe3-to-pe1pe4-1, ID: 2502
SIG-Protocol: LDP
Attachment-Circuit :UP
```

```
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
Interface: xe4
Service-template : vpls-pe3-to-pe1pe4-1
Match criteria : 2502
Action type : Translate
Action value : 2600
Outgoing tpid : dot1.q


Mesh Peers:
10.143.73.1 (Up)
Virtual Private LAN Service Instance: vpls-pe3-to-pe1pe4-2, ID: 2503


SIG-Protocol: BGP
Route-Distinguisher :100:2503
Route-Target :100:2503
VE-ID :4
Attachment-Circuit :UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
Interface: xe4
Service-template : vpls-pe3-to-pe1pe4-2
Match criteria : 2503/2504
Action type : Push
Action value : 2505


Mesh Peers:
10.143.73.1 (Up)

PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
(e) - Service mapped over MPLS Multipath/ECMP
================+===========+=========+===============+=========+=========+=========+=========+============+=========+======
======+========
Local Remote MPLS-Multipath Underlay
Destination Status VPN-ID Policy MC-Label UC-Label MC-Label UC-Label Grp-Name NHLFE-ix NW-Intf NW-Label
================+===========+=========+===============+=========+=========+=========+=========+============+=========+======
======+========
10.143.73.1 Installed 500 -- 640 17 640 -- -- -- xe7 16001
Total number of entries are 1

PE2#show evpn mpls xconnect tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
(e) - Service mapped over MPLS Multipath/ECMP
================+===========+=========+=========+===============+=========+=========+============+=========+============+===
======
Local Remote Local Remote MPLS-Multipath Underlay
Destination Status VPWS-ID VPWS-ID Policy UC-Label UC-Label Grp-Name NHLFE-ix NW-Intf NW-Label
================+===========+=========+=========+===============+=========+=========+============+=========+============+===
======
10.143.73.1 Installed 252 2 -- 16 16 -- -- xe7 16001
Total number of entries are 1
PE2#show mpls vrf-table
Output for IPv4 VRF table with id: 4
Primary FTN entry with FEC: 170.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
VRF id 4, BGP peer 10.143.73.1 BGP prefix 170.1.1.0
Transport Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, , Color: 0
```

```
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5

Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe7, transport out intf: xe7, out label: 25664
Nexthop addr: 10.143.73.1 cross connect ix: 4, op code: Push and Lookup

Output for IPv6 VRF table with id: 4
Primary FTN entry with FEC: 1111::/64, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
VRF id 4, BGP peer a8f:4901:: BGP prefix 1111::
Transport Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, , Color: 0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: BGP, Stale: NO, BGP out intf: xe7, transport out intf: xe7, out label: 25664
Nexthop addr: 10.143.73.1 cross connect ix: 4, op code: Push and Lookup

PE2#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport, (e) - FTN is ECMP
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
O> 10.143.73.1/32 1 9 0 Yes LSP_DEFAULT 16001 xe7 No 10.255.128.23
O> 10.143.73.5/32 2 10 0 Yes LSP_DEFAULT 3 xe7 No 10.255.128.23
O> 10.143.73.6/32 3 14 0 Yes LSP_DEFAULT 3 xe5 No 10.255.128.25
PE2#show mpls forwarding-table detail
FEC prefix: 10.143.73.1/32, FTN-ID: 1
Owner: OSPF-SR, FTN type: Regular, State: Installed
Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
LSP-ID: N/A, LSP-type: Primary
NHLFE-id: 9
Out-Label: 16001, Out-Intf: xe7, Nexthop: 10.255.128.23
Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
ELC: No
FEC prefix: 10.143.73.5/32, FTN-ID: 2
Owner: OSPF-SR, FTN type: Regular, State: Installed
Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
LSP-ID: N/A, LSP-type: Primary
NHLFE-id: 10
Out-Label: 3, Out-Intf: xe7, Nexthop: 10.255.128.23
Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
ELC: No
FEC prefix: 10.143.73.6/32, FTN-ID: 3
Owner: OSPF-SR, FTN type: Regular, State: Installed
Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
LSP-ID: N/A, LSP-type: Primary
NHLFE-id: 14
Out-Label: 3, Out-Intf: xe5, Nexthop: 10.255.128.25
Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
```

Note: The following CLI will be used to change from dedicated mode to best effort

```
 tunnel-policy PE1-P1-PE3
  color 1
  mode best-effort
```

CHAPTER 16 Mapping RSVP Tunnel Name to L2VPN Service

This chapter shows configurations of mapping of rsvp tunnel-name to L2VPN service.

An MPLS Layer 2 Virtual Circuit (VC) is a point-to-point Layer 2 connection transported via MPLS on the service provider's network. The Layer 2 circuit is transported over a single Label Switched Path (LSP) tunnel between two Provider Edge (PE) routers

Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP-MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. A set of Martini circuits is grouped by a common VPLS identifier to achieve this service objective

Overview

This topology will be applicable for both VPWS and VPLS services.

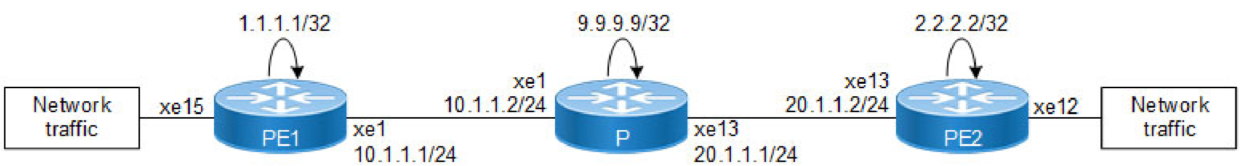


Figure 16-7: Mapping of RSVP Tunnel-name to L2VPN services

Configuring the VC:

Note: Loopback addresses being used should be advertised through OSPF, or should be statically routed.

1. Configure the IP address and OSPF for the PE1, P (Provider), and PE2 routers.
2. Configure MPLS and LDP on PE1, P, and PE2, and LDP targeted peer for the PE1 and PE2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE1 and PE2, and RSVP must be configured on PE1, P, and PE2).
3. Configure the VC with trunk-name.
4. Bind the customer interface to the VC.

Configure IP Address and OSPF on Routers

Configure the IP addresses and OSPF on the PE1, P, and PE2 routers.

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface (lo0) to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to 1.1.1.1/32.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the interface (xe1) to be configured.

`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#ip address 10.1.1.1/24`	Set the IP address of the interface to 10.1.1.1/24.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 10.1.1.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 1.1.1.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.

P

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface (lo0) to be configured.
`(config-if)#ip address 9.9.9.9/32 secondary`	Set the IP address of the loopback interface to 9.9.9.9/32.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the interface (xe1) to be configured.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#ip address 10.1.1.2/24`	Set the IP address of the interface to 10.1.1.2/24.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe13`	Specify the interface (xe13) to be configured.
`(config-if)#label-switching`	Enable label switching on interface xe13.
`(config-if)#ip address 20.1.1.1/24`	Set the IP address of the interface to 20.1.1.1/24.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 10.1.1.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 20.1.1.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 9.9.9.9/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.

PE2

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface (lo0) to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to 2.2.2.2/32.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe13`	Specify the interface (xe13) to be configured.
`(config-if)#label-switching`	Enable label switching on interface xe13.

(config-if)#ip address 20.1.1.2/24	Set the IP address of the interface to 20.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 20.1.1.0/24 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

Configure MPLS, RSVP, and LDP Targeted Peer on Routers

Configure MPLS and LDP on PE1, P, and PE2, and LDP targeted peers on PE1 and PE2.

Note: If RSVP is used for configuring trunks, LDP must be configured on PE1 and PE2, and RSVP must be configured on PE1, P, and PE2.

PE1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config-router)#router-id 1.1.1.1	Configure the router-id
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 2.2.2.2	Specify the targeted LDP peer on PE1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#exit	Exit configuration mode of the router.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#rsvp-trunk t2	Configure RSVP trunk t2
(config-trunk)#to 2.2.2.2	Configure PE2 as the end of trunk
(config-trunk)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config)#exit	Exit configuration mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.

(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe13	Specify the interface (xe13) to be configured.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#rsvp-trunk t5	Configure RSVP trunk t5
(config-trunk)#to 2.2.2.2	Configure PE2 as the end of trunk
(config-trunk)#exit	Exit configuration mode
(config)#rsvp-trunk t6	Configure RSVP trunk t6
(config-trunk)#to 1.1.1.1	Configure PE2 as the end of trunk
(config-trunk)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config-router)#router-id 2.2.2.2	Configure the router-id
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE2.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#router rsvp	Enter RSVP configuration mode for the router.
(config-router)#exit	Exit configuration mode of the router.
(config)#interface xe13	Specify the interface(xe13) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe13.
(config-if)#enable-rsvp	Enable RSVP on the interface.
(config-if)#exit	Exit interface mode.
(config)#rsvp-trunk t3	Configure RSVP trunk t3
(config-trunk)#to 1.1.1.1	Configure PE1 as the end of trunk
(config-trunk)#commit	Commit the transaction.

Configure VC

Configure the VC. Each VC ID uniquely identifies the Layer-2 circuit among all the Layer-2 circuits.

Note: Both PE routers (endpoints) must be configured with the same VC-ID (100 in this example).

PE1

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t2 100 2.2.2.2	Configure the VC for PE2. In this example, t2 is the VC name, 200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address

(config-pseudowire)#tunnel-name t2	Configure the RSVP Trunk name as t2
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#mpls l2-circuit t3 300 2.2.2.2 mode raw	Configure the VC for PE2. In this example, t3 is the VC-name, 300 is the VC ID and 2.2.2.2 is the VC endpoint IP address
(config-pseudowire)#tunnel-name t2	Configure RSVP Trunk name as t2
(config-pseudowire)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t2 100 1.1.1.1	Configure the VC for PE1. In this example, t2 is the VC name, 200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address
(config-pseudowire)#tunnel-name t3	Configure RSVP Tunnel name as t3
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#mpls l2-circuit t2 100 1.1.1.1	Configure the VC for PE1. In this example, t2 is the VC name, 200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address using rsvp trunk name t2
(config-pseudowire)#tunnel-name t3	Configure RSVP Tunnel name as t2
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#mpls l2-circuit t3 300 1.1.1.1 mode raw	Configure the VC for PE1. In this example, t3 is the VC name, 300 is the VC ID, and 1.1.1.1 is the VC endpoint IP address
(config-pseudowire)#tunnel-name t3	Configure RSVP Tunnel name as t3
(config-pseudowire)#commit	Commit the transaction.

Bind Customer Interface to VC

The following configuration allows only VLAN 2 and 3 traffic.

PE1

(config)#service-template ST1	Create a service template ST1
(config-svc)#match outer-vlan 2	Allow VLAN 2 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#service-template ST2	Create a service template ST2
(config-svc)#match outer-vlan 3	Allow VLAN 3 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#interface xe15	Specify the interface (xe15) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#mpls-l2-circuit t3 service-template ST2	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

PE2

(config)#service-template ST1	Create a service template ST1
(config-svc)#match outer-vlan 2	Allow VLAN 2 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#service-template ST2	Create a service template ST2
(config-svc)#match outer-vlan 3	Allow VLAN 3 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#interface xe12	Specify the interface (xe12) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#mpls-l2-circuit t3 service-template ST2	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

Validation

Use the show ldp mpls-l2-circuit (Control Plane) command, and the show mpls vc-table (Forwarding Plane) command, to display complete information about the Layer 2 VC.

If the VC State is UP in the output from the show ldp mpls-l2 circuit command, and the Status is Active in the output of the show mpls vc-table command, a ping from CE1 to CE2 should be successful.

Below are the sample output for VPWS service with Tunnel name:

```
PE1#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop         Status
100         N/A      N/A            xe15          xe1           24320      24321         2.2.2.2         Active
300         N/A      N/A            xe15          xe1           24321      24321         2.2.2.2         Active
PE1#

PE1#show ldp mpls-l2-circuit
Transport     Client     VC     VC             Local       Remote      Destination
VC ID         Binding    State  Type           VC Label    VC Label    Address
300           xe15       UP     Ethernet       24321       24321       2.2.2.2
100           xe15       UP     Ethernet VLAN  24320       24320       2.2.2.2
PE1#

PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t2, id: 100  PW-INDEX: 1 Tunnel-Name: t2
 Endpoint: 2.2.2.2
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe15
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : ST1
  Match criteria : 2


MPLS Layer-2 Virtual Circuit: t3, id: 300  PW-INDEX: 2 Tunnel-Name: t2
 Operating mode: Raw
 Endpoint: 2.2.2.2
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe15
 Virtual Circuit Type: Ethernet
```

```
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : ST2
  Match criteria : 3

PE1#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe5,up,AC state is up
Session IF: xe2, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 26881, remote label: 53760
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:02:12

PW ID: 100, VC state is up
Access IF: xe5,up,AC state is up
Session IF: xe2, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26880, remote label: 53761
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:02:12
```

PE2

```
PE2#sh mpls vc-table
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe12 xe3 26880 25600 1.1.1.1 Active
300 N/A N/A xe12 xe3 26881 25600 1.1.1.1 Active
PE2#sh ldp mpls-l2-circuit
Transport Client VC VC Local Remote Destination
VC ID Binding State Type VC Label VC Label Address
300 xe12 UP Ethernet 53760 26881 1.1.1.1
100 xe12 UP Ethernet VLAN 53761 26880 1.1.1.1

PE2#sh mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t2, id: 100 PW-INDEX: 1 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2

MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 service-tpid: dot1.q
Tunnel-Name: t3

Operating mode: Raw
```

```
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2
Match criteria : 3


PE2#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 53760, remote label: 26881
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:05:34

PW ID: 100, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 53761, remote label: 26880
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:05:34



These additional commands can also be used to display information about the Layer 2 virtual circuits.
show ldp mpls-l2-circuit detail
show ldp mpls-l2-circuit VC-ID
show ldp mpls-l2-circuit VC-ID detail
show mpls l2-circuit
```

Configuring a MPLS Static Layer-2 VC

1. Configure the VC with the manual option using tunnel name
2. Configure the VC FIB entry.
3. Bind the VC; all steps are in the configurations that follow.

PE1

`#configure terminal`	Enter configure mode.
`PE1(config)#mpls l2-circuit t5 500 2.2.2.2`	Configure the VC for PE1
`PE1(config-pseudowire)#tunnel-name t2`	Configure the RSVP Tunnel name as t2
`PE1(config-pseudowire)#manual-pseudowire`	Configure the VC as manual (no signaling is used)
`PE1(config-pseudowire)#exit`	Exit pseudowire config mode.
`PE1(config)#service-template ST5`	Create a service template ST5
`PE1(config-svc)#match outer-vlan 5`	Configure single match criteria vlan 5
`PE1(config-svc)#exit`	Exit the service template mode
`PE1(config)#interface xe15`	Access interface xe15
`(config-if)#switchport`	Switch to Layer-2 mode.
`PE1(config-if)#mpls-l2-circuit t5 service-template ST5`	Bind the interface to the VC with service template.
`PE1(config-if)#exit`	Exit interface mode
`PE1(config-if)#commit`	Commit the transaction.
`PE1(config)#mpls l2-circuit-fib-entry 500 1000 2000 2.2.2.2 xe1 xe15`	Add an FTN entry; where 1000 is the incoming label, 2000 is the outgoing label, 2.2.2.2 is the endpoint, xe1 is the Provider facing interface name, and xe15 is access interface name
`PE1(config)#commit`	Commit the transaction.

PE2

`#configure terminal`	Enter configure mode.
`PE2(config)#mpls l2-circuit t5 500 1.1.1.1`	Configure the VC for PE2
`PE2(config-pseudowire)#tunnel-name t3`	Configure RSVP Tunnel name as t3
`PE2(config-pseudowire)#manual-pseudowire`	Configure VC as manual (no signaling used)
`PE2(config-pseudowire)#exit`	Exit pseudowire config mode.
`PE2(config)#service-template ST5`	Create a service template ST5
`PE2(config-svc)#match outer-vlan 5`	Configure single match criteria vlan 5
`PE2(config-svc)#exit`	Exit the service template mode
`PE2(config)#interface xe12`	Access interface xe12
`(config-if)#switchport`	Switch to Layer-2 mode.
`PE2(config-if)#mpls-l2-circuit t5 service-template ST5`	Bind the interface to the VC with service template.
`PE2(config-if)#exit`	Exit interface mode.
`PE2(config-if)#commit`	Commit the transaction.
`PE1(config)#mpls l2-circuit-fib-entry 500 2000 1000 1.1.1.1 xe13 xe12`	Add an FTN entry; where 2000 is the incoming label, 1000 is the outgoing label, 1.1.1.1 is the endpoint, xe12 is the Provider facing interface name, and xe13 access interface name
`PE1(config)#commit`	Commit the transaction.
`PE2(config)#exit`	Exit configure mode

Validation

This example shows number of configured VCs and its status.

```
PE1#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop         Status
100         N/A      N/A            xe15          xe1           24320      24321         2.2.2.2         Active
300         N/A      N/A            xe15          xe1           24321      24321         2.2.2.2         Active
500         N/A      N/A            xe15          xe1           2000       24321         2.2.2.2         Active

PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t2, id: 100  PW-INDEX: 1 Tunnel-Name: t2
 Endpoint: 2.2.2.2
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe15
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : ST1
  Match criteria : 2


MPLS Layer-2 Virtual Circuit: t3, id: 300  PW-INDEX: 2 Tunnel-Name: t2
 Operating mode: Raw
 Endpoint: 2.2.2.2
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe15
 Virtual Circuit Type: Ethernet
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : ST2
  Match criteria : 3


MPLS Layer-2 Virtual Circuit: t5, id: 500  PW-INDEX: 3 Tunnel-Name: t2
 Endpoint: 2.2.2.2
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe15
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : ST5
  Match criteria : 5


PE1#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up


Access IF: xe15,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 26881, remote label: 53760
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:15:48
PW ID: 100, VC state is up
Access IF: xe5,up,AC state is up
Session IF: xe1, state is up
```

```
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26880, remote label: 53761
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:15:48
```

PE2

```
OcNOS#sh mpls vc-table

VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe12 xe3 26880 25600 1.1.1.1 Active
300 N/A N/A xe12 xe3 26881 25600 1.1.1.1 Active
500 N/A N/A xe12 xe3 1000 25600 1.1.1.1 Active
PE2#sh mpls l2-circuit

MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2

MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 service-tpid: dot1.q
Tunnel-Name: t3
Operating mode: Raw
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2
Match criteria : 3

MPLS Layer-2 Virtual Circuit: t5, id: 500 PW-INDEX: 3 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST5
Match criteria : 5

OcNOS#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: ethernet, remote vctype :ethernet
```

```
Local groupid: 0, remote groupid: 0
Local label: 53760, remote label: 26881
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled

MPLS Layer-2 Virtual Circuit: t2, id: 100 PW-INDEX: 1 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No

MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST1
Match criteria : 2

MPLS Layer-2 Virtual Circuit: t3, id: 300 PW-INDEX: 2 service-tpid: dot1.q
Tunnel-Name: t3
Operating mode: Raw
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST2

Match criteria : 3
MPLS Layer-2 Virtual Circuit: t5, id: 500 PW-INDEX: 3 service-tpid: dot1.q
Tunnel-Name: t3
Endpoint: 1.1.1.1
Control Word: 0
Flow Label Status: Disabled, Direction: None, Static: No
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe12
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : ST5

Match criteria : 5
OcNOS#show ldp mpls-l2-circuit detail
PW ID: 300, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: ethernet, remote vctype :ethernet
Local groupid: 0, remote groupid: 0
Local label: 53760, remote label: 26881
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:17:41
```

```
PW ID: 100, VC state is up
Access IF: xe12,up,AC state is up
Session IF: xe3, state is up
Destination: 1.1.1.1, Peer LDP Ident: 1.1.1.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 53761, remote label: 26880
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:17:41
```

These additional commands can also be used to display information about the Layer 2 virtual circuits.

```
show ldp mpls-l2-circuit detail
show ldp mpls-l2-circuit VC-ID
show ldp mpls-l2-circuit VC-ID detail
show mpls l2-circuit
```

Configure Dynamic VPLS

PE1: LDP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 2.2.2.2 tunnel-name t2	Configure VPLS Peer with trunk-name t2
(config-vpls-sig)#exit	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type ethernet	Type ethernet configuration for VPLS
(config-vpls-sig)#vpls-peer 2.2.2.2 tunnel-name t2	Configure VPLS Peer
(config-vpls-sig)#commit	Commit the transaction.
(config-vpls)#exit	Exit VPLS mode

PE2: LDP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS

(config-vpls-sig)#vpls-peer 1.1.1.1 tunnel-name t3	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type ethernet	Type ethernet configuration for VPLS
(config-vpls-sig)#vpls-peer 1.1.1.1 tunnel-name t3	Configure VPLS Peer with tunnel-name t2
(config-vpls-sig)#commit	Commit the transaction.
(config-vpls)#exit	Exit VPLS mode

LDP VPLS Service Mapping Configuration

PE1

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode
(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#commit	Commit the transaction.

PE1: Access port Configuration

(config)#interface xe15	Enter the access interface xe15.
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template4	Bind the VPLS to the Access Interface.

(config-if-vpls)#commit	Commit the transaction.
(config-if)#exit	Exit Interface mode and return to Configure mode.

PE2

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode
(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#commit	Commit the transaction.

PE2: Access port Configuration

(config)#interface xe12	Enter access Interface xe12
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#commit	Commit the transaction.
(config-if)#exit	Exit Interface mode and return to Configure mode.

Validation

Below are the example outputs of mpls vpls with tunnel-name

```
PE1#show mpls vpls mesh
VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St    PW-INDEX SIG-Protocol  Status
25         2.2.2.2           24321         24322      xe1            24322      2/Up       4         LDP           Active
26         2.2.2.2           24321         24323      xe1            24323      2/Up       5         LDP           Active
PE1#

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
```

```
 Description: none
 service-tpid: dot1.ad
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 88a8
 Configured interfaces:
  Interface: xe15
 Service-template : template1
  Match criteria : 2024/2023
  Action type : Pop
  Outgoing tpid : dot1.q

 Mesh Peers:
   2.2.2.2 (Up)
   Tunnel-Name: t2


Virtual Private LAN Service Instance: v2, ID: 26
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.ad
 Operating mode: Raw
 Configured interfaces:
  Interface: xe15
 Service-template : template4
  Match criteria : 700,
 1200/3200,
 Untagged
  Action type : Push
  Action value : 300

 Mesh Peers:
   2.2.2.2 (Up)
   Tunnel-Name: t2
```

PE2#

```
PE1#sh mpls vpls mesh


VPLS-ID  Peer     Tunnel-  In-Label Network- Out-     Lkps/St  PW-INDEX SIG-     Status
         Addr     Label             Intf     Label                      Protocol
25       2.2.2.2  24321    24322    Xe1      24322    2/Up     4        LDP      Active
26       2.2.2.2  24321    24323    Xe1      24323    2/Up     5        LDP      Active
PE1#
```

```
PE2#sh mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25 SIG-Protocol: LDP
Attachment-Circuit :UP Learning: Enabled Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500 Description: none
service-tpid: dot1.ad Operating mode: Tagged Svlan Id: 0
Svlan Tpid: 88a8 Configured interfaces:
Interface: xe15
Service-template : template1 Match criteria : 2024/2023 Action type : Pop
Outgoing tpid : dot1.q
Mesh Peers:
2.2.2.2 (Up) Tunnel-Name: t2


Virtual Private LAN Service Instance: v2, ID: 26 SIG-Protocol: LDP
Attachment-Circuit :UP Learning: Enabled Control-Word: Disabled
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500 Description: none
service-tpid: dot1.ad Operating mode: Raw Configured interfaces:
Interface: xe15
Service-template : template4 Match criteria : 700,
1200/3200,
Untagged
Action type : Push Action value : 300
Mesh Peers:
2.2.2.2 (Up) Tunnel-Name: t2
```

Configure Static VPLS

PE1: LDP VPLS Configuration

(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#vpls-peer 2.2.2.2 tunnel-name t2 manual	Configure VPLS Peer with trunk-name t2 with manual option
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls1	Template configuration
(config-svc)# match outer-vlan 1000	Allow VLAN 1000 traffic on this VC
(config-svc)#exit	Exit service template mode

PE1: Access port Configuration

(config)#interface xe15	Enter the access Interface xe15
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v3 service-template vpls1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit from the interface mode
(config)#vpls fib-entry 27 peer 2.2.2.2 3000 xe1 4000	Configure VPLS FIB entry for VPLS peer PE2
(config)#commit	Commit the transaction.

PE2: LDP VPLS Configuration

(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#vpls-peer 1.1.1.1 tunnel-name t3 manual	Configure static VPLS Peer with tunnel-name t3
(config-vpls)#exit	Exit VPLS mode
(config)#service-template vpls1	Template configuration
(config-svc)# match outer-vlan 1000	Allow VLAN 1000 traffic on this VC
(config-svc)#exit	Exit service template mode

PE2: Access port Configuration

(config)#interface xe12	Enter the access interface xe12
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v3 service-template vpls1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit-if-vpls	Exit VPLS attachment-circuit mode

(config-if)#exit	Exit interface mode.
(config)#vpls fib-entry 27 peer 1.1.1.1 4000 xe13 3000	Configure VPLS FIB entry for VPLS peer PE1.
(config)#commit	Commit the transaction.

Validation

```
PE1#show mpls vpls mesh
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St   PW-INDEX SIG-Protocol  Status
25         2.2.2.2          24321         24322      xe1            24322      2/Up      4         LDP           Active
26         2.2.2.2          24321         24323      xe1            24323      2/Up      5         LDP           Active
27         2.2.2.2          24321         3000       xe1            4000       2/Up      6         STATIC        Active

PE1#show mpls vpls v3 detail
Virtual Private LAN Service Instance: v3, ID: 27
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe15
 Service-template : vpls1
  Match criteria : 1000

 Mesh Peers:
   2.2.2.2 (Up)
   Tunnel-Name: t2
```

PE2#

```
PE2#sh mpls vpls mesh

VPLS-ID  Peer     Tunnel-  In-Label Network- Out-     Lkps/St  PW-INDEX SIG-     Status
         Addr     Label             Intf     Label                      Protocol
25       2.2.2.2  24321    24322    xe1      24322    2/Up     4        LDP      Active
26       2.2.2.2  24321    24323    xe1      24323    2/Up     5        LDP      Active
27       2.2.2.2  24321    3000     xe1      4000     2/Up     6        STATIC   Active
PE2#

PE2#sh mpls vpls v3 detail
Virtual Private LAN Service Instance: v3, ID: 27 SIG-Protocol: STATIC
Attachment-Circuit :UP Learning: Enabled Control-Word: Disabled
Group ID: 0, Configured MTU: 1500 Description: none
service-tpid: dot1.q Operating mode: Raw Configured interfaces:
Interface: xe15
Service-template : vpls1 Match criteria : 1000
```

Mesh Peers:

```
2.2.2.2 (Up) Tunnel-Name: t2
```

CHAPTER 17 MPLS BFD Configuration

This chapter shows how to configure MPLS-LSP-BFD and PW-VCCV-BFD

BFD can be used to track the liveliness of MPLS LSP and also can be used as one of the CV mechanisms in VCCV for PW fault detection and status signaling.

Qumran1 and Qumran2 series platforms support VCCV BFD with the following restrictions:

Qumran 1 Series Platforms	Qumran 2 Series Platforms
Supports both cc-type 1 and 2	Supports only cc-type 1 and cv-type 1 and 3

Topology

Figure 17-8 shows the configuration required to enable MPLS LSP BFD.

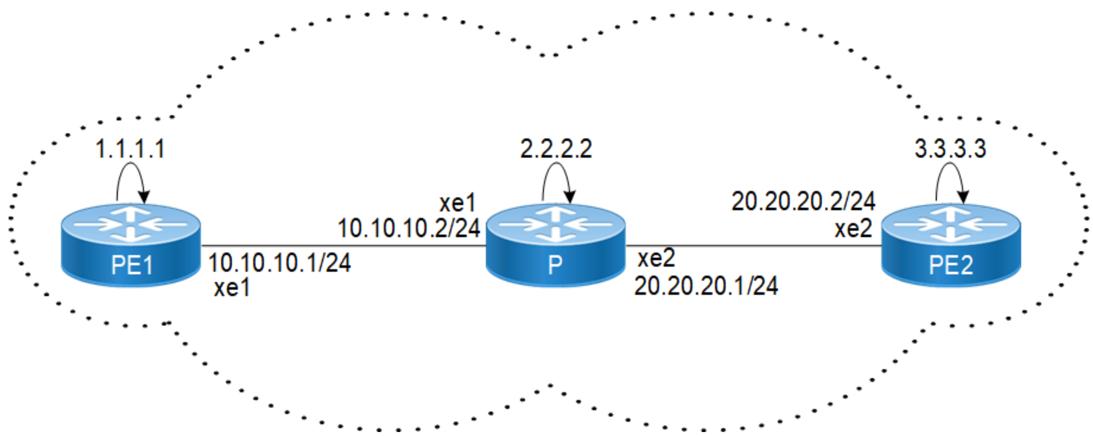


Figure 17-8: MPLS LSP BFD Topology

Configuring MPLS BFD LSP over LDP

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to 1.1.1.1/32.
`(conf)#interface eth1`	Enter interface mode
`(conf-if)#ip address 10.10.10.1/24`	Assign IP address to eth1 interface
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#enable-ldp ipv4`	Enable LDP on eth1.
`(confi-if)#exit`	Exit interface mode

`(config)#router ldp`	Enter Router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`(config-router)#exit`	Exit the Router mode and return to the Configure mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 10.10.10.0/24 area 0`	Advertise the eth1 interface in OSPF area 0.
`(config-router)#network 1.1.1.1/32 area 0`	Advertise the lo interface in OSPF area 0.
`(config-router)#exit`	Exit router mode
`(config)#mpls bfd ldp all`	Configure mpls bfd for ldp
`(config-mpls-bfd)#exit`	Exit mpls bfd mode
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#end`	Exit out of configuration terminal mode

P

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to 2.2.2.2/32.
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth1`	Specify the interface (eth1) to be configured.
`(conf-if)#ip address 10.10.10.2/24`	Assign IP address to eth1 interface
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#enable-ldp ipv4`	Enable LDP on a specified interface (eth1).
`(config-if)#exit`	Exit interface mode.
`(config)#interface eth2`	Specify the interface (eth2) to be configured.
`(conf-if)#ip address 20.20.20.1/24`	Assign IP address to eth2 interface
`(config-if)#label-switching`	Enable label switching on interface eth2.
`(config-if)#enable-ldp ipv4`	Enable LDP on a specified interface (eth2).
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter Router mode.
`(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2.
`(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
`(config-router)#exit`	Exit Router mode and return to Configure mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

(config-router)#network 10.10.10.0/24 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#network 20.20.20.0/24 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#network 2.2.2.2/32 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config)#mpls bfd ldp all	Configure mpls bfd for ldp
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(conf-if)#ip address 20.20.20.2/24	Assign IP address to eth2 interface
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth2).
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit Interface mode
(config)#router ldp	Enter Router mode.
(config-router)#router-id 3.3.3.3	Set the router ID for IP address 3.3.3.3.
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 20.20.20.0/24 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#network 3.3.3.3/32 area 0	Define the interfaces on which OSPF runs and associate the area ID (0) with them.
(config-router)#commit	Commit the transaction.
(config)#mpls bfd ldp all	Configure mpls bfd for ldp
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

Validation

Validation 1

Verify OSPF neighbor adjacency between all 5 routers.

```
PE1#show ip ospf neighbor

Total number of full neighbors: 1
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/DR         00:00:32   10.10.10.2     eth1
0

P#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
1.1.1.1          1   Full/Backup     00:00:35   10.10.10.1     eth1
0
3.3.3.3          1   Full/Backup     00:00:32   20.20.20.2     eth2
0

PE2#show ip ospf neighbor

Total number of full neighbors: 1
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/DR         00:00:31   20.20.20.1     eth1
0
```

Validation 2

Verify that ldp session on all 3 nodes have come up.

```
PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2                   eth1        Passive   OPERATIONAL   30    01:30:57

P#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
1.1.1.1                   eth1        Active    OPERATIONAL   30    01:48:34
3.3.3.3                   eth2        Passive   OPERATIONAL   30    03:01:14

PE2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2                   eth2        Active    OPERATIONAL   30    03:01:14
```

Validation 3

The command output below displays the LSP sessions with LDP as signaling protocol.

```
PE1# #show bfd mpls lsp sessions
 Peer Addr                  Path      Tunnel-name                      State    Local
Local  Min         Min        Encap   Last
                                                                                Disc
Multi  Tx          Rx                 Dn-Time
 2.2.2.2                    LDP LSP                                    Up       1281
3      10000       10000      IP/UDP  00:00:00
 3.3.3.3                    LDP LSP                                    Up       1282
3      10000       10000      IP/UDP  00:00:00
 0.0.0.0                    LDP LSP                                    Up       1283
3      3000        3000       IP/UDP  00:00:00
 0.0.0.0                    LDP LSP                                    Up       1284
3      3000        3000       IP/UDP  00:00:00

P #show bfd mpls lsp sessions
 Peer Addr                  Path      Tunnel-name                      State    Local
Local  Min         Min        Encap   Last
                                                                                Disc
Multi  Tx          Rx                 Dn-Time
 3.3.3.3                    LDP LSP                                    Up       1283
3      10000       10000      IP/UDP  00:00:00
 0.0.0.0                    LDP LSP                                    Up       1281
3      3000        3000       IP/UDP  00:00:00
 1.1.1.1                    LDP LSP                                    Up       1282
3      10000       10000      IP/UDP  00:00:00
 0.0.0.0                    LDP LSP                                    Up       1284
3      3000        3000       IP/UDP  00:00:00

PE1 #show bfd mpls lsp sessions
 Peer Addr                  Path      Tunnel-name                      State    Local
Local  Min         Min        Encap   Last
                                                                                Disc
Multi  Tx          Rx                 Dn-Time
 2.2.2.2                    LDP LSP                                    Up       1282
3      10000       10000      IP/UDP  00:00:00
 0.0.0.0                    LDP LSP                                    Up       1283
3      3000        3000       IP/UDP  00:00:00
 1.1.1.1                    LDP LSP                                    Up       1281
3      10000       10000      IP/UDP  00:00:00
 0.0.0.0                    LDP LSP                                    Up       1284
3      3000        3000       IP/UDP  00:00:00
```

Configuring MPLS BFD LSP over RSVP

This section shows how to configure RSVP session between PE1 and PE2 and MPLS BFD.

Note: For OSPF configurations, please refer 'Configuring MPLS BFD LSP over LDP' section.

PE1

`(config)#router rsvp`	Enter Router mode for RSVP.
`(config-router)#exit`	Exit RSVP router mode
`(conf)#interface eth1`	Enter interface mode
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#enable-rsvp`	Enable RSVP on eth1.
`(confi-if)#exit`	Exit interface mode
`(config)#rsvp-trunk T1 ipv4`	Configure Trunk for RSVP
`(config-trunk)# from 1.1.1.1`	Specify tunnel ingress for RSVP
`(config-trunk)# to 3.3.3.3`	Specify tunnel egress for RSVP
`(config-trunk)#exit`	Exit RSVP trunk configuration mode
`(config)#mpls bfd rsvp all`	Configure mpls bfd for RSVP
`(config-mpls-bfd)#exit`	Exit mpls bfd mode
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#end`	Exit out of configuration terminal mode

P

`(config)#router rsvp`	Enter Router mode for RSVP.
`(config-router)#exit`	Exit RSVP router mode
`(conf)#interface eth1`	Enter interface mode
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#enable-rsvp`	Enable RSVP on eth1.
`(confi-if)#exit`	Exit interface mode
`(conf)#interface eth2`	Enter interface mode
`(config-if)#label-switching`	Enable label switching on interface eth2.
`(config-if)#enable-rsvp`	Enable RSVP on eth2.
`(confi-if)#exit`	Exit interface mode
`(config)#mpls bfd rsvp all`	Configure mpls bfd for RSVP
`(config-mpls-bfd)#exit`	Exit mpls bfd mode
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#end`	Exit out of configuration terminal mode

PE2

(config)#router rsvp	Enter Router mode for RSVP.
(config-router)#exit	Exit RSVP router mode
(conf)#interface eth2	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-rsvp	Enable RSVP on eth2.
(confi-if)#exit	Exit interface mode
(config)#rsvp-trunk T1 ipv4	Configure Trunk for RSVP
(config-trunk)# from 3.3.3.3	Specify tunnel ingress for RSVP
(config-trunk)# to 1.1.1.1	Specify tunnel egress for RSVP
(config-trunk)#exit	Exit RSVP trunk configuration mode
(config)#mpls bfd rsvp all	Configure mpls bfd for RSVP
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

Validation

Validation 1

Verify RSVP session is up and running between PE nodes.

```
PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Type    LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
3.3.3.3          1.1.1.1          PRI     T1-Primary                       UP    00:35:38
1 1 SE     -        24321     DEFAULT
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Type    LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
1.1.1.1          3.3.3.3          PRI     T1-Primary                       UP    00:35:51
1 1 SE     24320    -         ELSP_CON
Total 1 displayed, Up 1, Down 0.

PE2#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
```

```
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Type    LSPName                         State Uptime    Rt
Style  Labelin  Labelout  DSType
1.1.1.1         3.3.3.3          PRI     T1-Primary                         UP    00:37:51
1 1 SE     -        24320     DEFAULT
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Type    LSPName                         State Uptime    Rt
Style  Labelin  Labelout  DSType
3.3.3.3         1.1.1.1          PRI     T1-Primary                         UP    00:37:38
1 1 SE     24320    -         ELSP_CON
```

Validation 2

The command output below displays the LSP sessions with RSVP.

```
PE1#show bfd mpls lsp sessions
 Peer Addr                   Path       Tunnel-name                    State    Local
Local  Min        Min         Encap   Last
                                                                              Disc
Multi  Tx         Rx                  Dn-Time
3.3.3.3                     RSVP LSP   T1                               Up       1282
3      10000      10000      IP/UDP  00:00:00
PE2#show bfd mpls lsp sessions
 Peer Addr                   Path       Tunnel-name                    State    Local
Local  Min        Min         Encap   Last
                                                                              Disc
Multi  Tx         Rx                  Dn-Time
 1.1.1.1                     RSVP LSP   T1                              Up       1281
3      10000      10000      IP/UDP  00:00:00
```

Configuring Static MPLS BFD

This section shows how to configure MPLS BFD statically.

Note: For OSPF configurations, please refer 'Configuring MPLS BFD LSP over LDP' section.

PE1

(config)#interface eth1	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#exit	Exit interface mode
(conf)#mpls ftn-entry 3.3.3.3/32 102 10.10.10.2 eth1	Configure MPLS FTN entry for the creation of a static LSP to

PE-2.	
(config)#mpls ilm-entry 401 pop	Configure ILM entry
(config)#mpls bfd static all	Configure mpls bfd for static MPLS
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

P

(config)#interface eth1	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth1.
(confi-if)#exit	Exit interface mode
(conf)#interface eth2	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode
mpls ilm-entry 201 swap 401 eth1 10.10.10.1 1.1.1.1/32	Swap the incoming label
mpls ilm-entry 102 swap 301 eth2 mpls ftn-entry 1.1.1.1/32 201 20.20.20.1 eth2 20.20.20.2 3.3.3.3/32	Swap the incoming label
(config)#mpls bfd static all	Configure mpls bfd for static MPLS
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

PE2

(conf)#interface eth2	Enter interface mode
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#exit	Exit interface mode
(config)#mpls ftn-entry 1.1.1.1/32 201 20.20.20.1 eth2	Configure MPLS FTN entry for the creation of a static LSP to
PE-1	
(config)#mpls bfd static all	Configure mpls bfd for static MPLS
(config-mpls-bfd)#exit	Exit mpls bfd mode
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit out of configuration terminal mode

Validations

Validation 1

Verify static MPLS BFD session is up and running between PE nodes.

```
PE1#show bfd mpls lsp sessions
 Peer Addr                  Path      Tunnel-name                         State    Local
Local  Min        Min        Encap   Last
                                                                                   Disc
Multi  Tx         Rx                 Dn-Time
 3.3.3.3                    Static LSP                                    Up       1281
3      10000      10000      IP/UDP  00:00:00

PE2#show bfd mpls lsp sessions
 Peer Addr                  Path      Tunnel-name                         State    Local
Local  Min        Min        Encap   Last
                                                                                   Disc
Multi  Tx         Rx                 Dn-Time
 1.1.1.1                    Static LSP                                    Up       1281
3      10000      10000      IP/UDP  00:00:00
```

Configuring PW VCCV BFD

This section shows how to configure PW VCCV BFD.

Note: For OSPF configurations, please refer 'Configuring MPLS BFD LSP over LDP' section.

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to 1.1.1.1/32.
`(conf)#interface eth1`	Enter interface mode
`(conf-if)#ip address 10.10.10.1/24`	Assign IP address to eth1 interface
`(config-if)#label-switching`	Enable label switching on interface eth1.
`(config-if)#enable-ldp ipv4`	Enable LDP on eth1.
`(confi-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter Router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`(config-router)#exit`	Exit the Router mode and return to the Configure mode.
`(config)#service-template st1`	Service template configuration
`(config-svc)#exit`	Exit service-template configuration mode
`(config)#mpls l2-circuit pw1 3.3.3.3`	Configure the VC for PE2

(config-pseudowire)#control-word	Configure control-word
(config-pseudowire)#vccv cc-type type-1	Configure cc-type type-1
(config-pseudowire)#vccv cv-type type-3	Configure cv-type type-3
(confi- pseudowire)#exit	Exit pw configuration mode
(config)#commit	Commit the candidate configuration to the running configuration

P

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(conf-if)#ip address 10.10.10.2/24	Assign IP address to eth1 interface
(config-if)#label-switching	Enable label switching on interface eth1.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth1).
(config-if)#exit	Exit interface mode.
(config)#interface eth2	Specify the interface (eth2) to be configured.
(conf-if)#ip address 20.20.20.1/24	Assign IP address to eth2 interface
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth2).
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter Router mode.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#pw-status-tlv	Configure PW Status TLV to signal the pseudowire status
(config-router)#exit	Exit Router mode and return to Configure mode.
(config)#commit	Commit the candidate configuration to the running configuration

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode.
(config)#interface eth1	Specify the interface (eth1) to be configured.
(conf-if)#ip address 20.20.20.2/24	Assign IP address to eth1 interface
(config-if)#label-switching	Enable label switching on interface eth2.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (eth2).
(config-if)#commit	Commit the transaction.

`(config-if)#exit`	Exit Interface mode
`(config)#router ldp`	Enter Router mode.
`(config-router)#router-id 3.3.3.3`	Set the router ID for IP address 3.3.3.3.
`(config-router)#transport-address ipv4 3.3.3.3`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`(config-router)#exit`	Exit the Router mode and return to the Configure mode.
`(config)#service-template st1`	Service template configuration
`(config-svc)#exit`	Exit service-template configuration mode
`(config)#mpls l2-circuit pw1 1.1.1.1`	Configure the VC for PE1
`(config-pseudowire)#control-word`	Configure control-word
`(config-pseudowire)#vccv cc-type type-1`	Configure cc-type type-1
`(config-pseudowire)#vccv cv-type type-3`	Configure cv-type type-3
`(confi- pseudowire)#exit`	Exit pw configuration mode

Validation

Validation 1

Verify PW VCCV BFD sessions are up between PE nodes.

```
PE1#show bfd mpls pw-vccv sessions
 VC-ID      Peer Addr                    State    Local     Local  Min        Min
Encap   Last
                                              Disc      Multi  Tx        Rx
Dn-Time
 1          3.3.3.3                 Up       1281      3      3000       3000       PW-
ACH  00:00:00

PE2#show bfd mpls pw-vccv sessions
 VC-ID      Peer Addr                    State    Local     Local  Min        Min
Encap   Last
                                              Disc      Multi  Tx        Rx
Dn-Time
 1          1.1.1.1                 Up       1281      3      3000       3000       PW-
ACH  00:00:00
```

CHAPTER 18 BGP Peer Groups for Address-Family L2VPN EVPN

BGP peer groups are used to simplify configuration and to improve performance. This is achieved by assigning the same outbound policy to each of the neighbors. Because UPDATEs are generated only once per peer group rather than multiple times for each neighboring router, peer groups save processing time when building neighbor updates. It reduces the amount of system resources (CPU and memory) necessary in an update generation.

A BGP peer group reduces the load on system resources by allowing the routing table to be checked only once, and updates to be replicated to all peer group members instead of being done individually for each peer in the peer group.

Topology

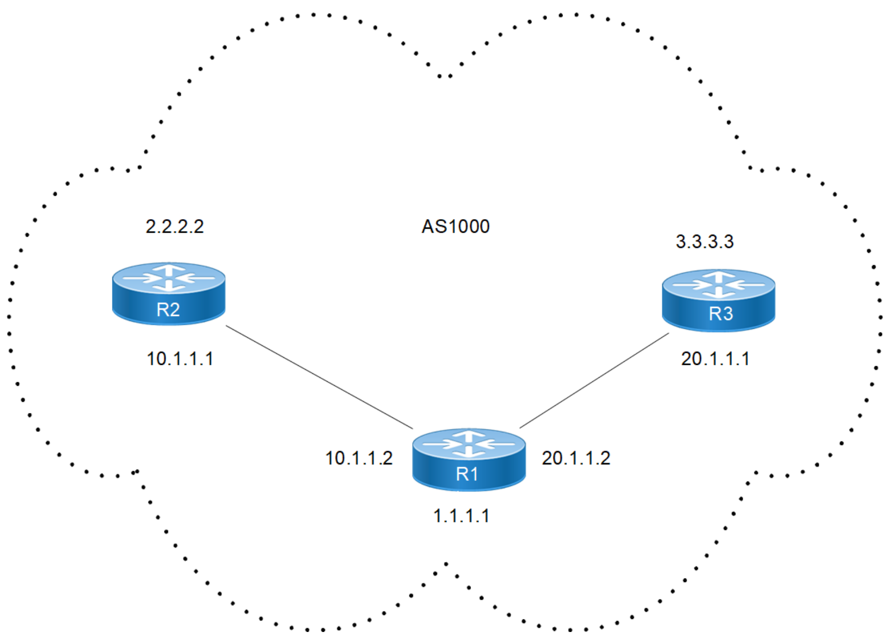


Figure 18-9: BGP Peer-Groups with L2VPN EVPN address-family

Configuration

R1

`#configure terminal`	Enter configure mode.
`(config)# interface lo`	Enter interface mode for Loopback
`(config-if)#ip address 1.1.1.1/32 secondary`	Configure ip address for Loopback interface
`(config-if)#exit`	Exit interface mode
`(config)# interface xe15`	Enter interface mode for xe15
`(config-if)#ip address 10.1.1.2/24`	Configure ip address
`(config-if)#exit`	Exit interface mode

`(config)# interface ce0`	Enter interface mode for ce0
`(config-if)#ip address 20.1.1.2`	Configure ip address
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 100`	Configure the OSPF process (100)
`(config-router)# ospf router-id 1.1.1.1`	Configure OSPF router-id
`(config-router)#network 1.1.1.1/32 area 0`	Advertise the network in Area 0
`(config-router)#network 10.1.1.0/24 area 0`	Advertise the network in Area 0
`(config-router)#network 20.1.1.0/24 area 0`	Advertise the network in Area 0
`(config-router)#exit`	Exit Router mode and return to Configure mode
`(config)#router bgp 100`	Define the routing process. The number 100 specifies the AS number of R1.
`(config-router)# bgp router-id 1.1.1.1`	Configure BGP router-id
`(config-router)#neighbor PG  peer-group`	Create a peer group named PG
`(config-router)#neighbor PG remote-as 100`	Assign options to the peer group named PG
`(config-router)#neighbor PG update-source lo`	Assign options to the peer group named PG
`(config-router)#neighbor 2.2.2.2 peer-group PG`	Define neighbor 2.2.2.2 (R2) as a peer group
`(config-router)#neighbor 3.3.3.3 peer-group PG`	Define neighbor 3.3.3.3 (R3) as a peer group member.
`(config-router)#address-family l2vpn evpn`	Enter address-family l2vpn evpn mode
`(config-router-af)#neighbor PG activate`	Activate the peer-group ABC for address-family l2vpn evpn
`(config-router-af)# exit-address-family`	Exit address-family ipv4 unicast mode
`(config-router)#exit`	Exit router bgp mode
`(config)#commit`	Commit the candidate configuration to the running configuration.

R2

`#configure terminal`	Enter configure mode.
`(config)# interface lo`	Enter interface mode for Loopback
`(config-if)#ip address 2.2.2.2/32 secondary`	Configure ip address for Loopback interface
`(config-if)#exit`	Exit interface mode
`(config)# interface xe15`	Enter interface mode for xe15
`(config-if)#ip address 10.1.1.2/24`	Configure ip address
`(config-if)#exit`	Exit interface mode
`(config)# interface xe10`	Enter interface mode for xe10
`(config-if)#ip address 10.1.1.1/24`	Configure ip address
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 100`	Configure the OSPF process (100)
`(config-router)# ospf router-id 2.2.2.2`	Configure OSPF router-id
`(config-router)#network 2.2.2.2/32 area 0`	Advertise the network in Area 0
`(config-router)#network 10.1.1.0/24 area 0`	Advertise the network in Area 0
`(config-router)#exit`	Exit Router mode and return to Configure mode

(config)#router bgp 100	Define the routing process. The number 100 specifies the AS number of R1.
(config-router)# bgp router-id 2.2.2.2	Configure BGP router-id
(config-router)#neighbor PG peer-group	Create a peer group named PG
(config-router)#neighbor PG remote-as 100	Assign options to the peer group named PG
(config-router)#neighbor PG update-source lo	Assign options to the peer group named PG
(config-router)#neighbor 1.1.1.1 peer-group PG	Define neighbor 1.1.1.1 (R1) as a peer group member.
(config-router)#address-family l2vpn evpn	Enter address-family l2vpn evpn mode
(config-router-af)#neighbor PG activate	Activate the peer-group ABC for address-family l2vpn evpn
(config-router-af)# exit-address-family	Exit address-family ipv4 unicast mode
(config-router)#exit	Exit router bgp mode
(config)#commit	Commit the candidate configuration to the running configuration.

R3

#configure terminal	Enter configure mode.
(config)# interface lo	Enter interface mode for Loopback
(config-if)#ip address 3.3.3.3/32 secondary	Configure ip address for Loopback interface
(config-if)#exit	Exit interface mode
(config)# interface ce15	Enter interface mode for ce15
(config-if)#ip address 20.1.1.1/24	Configure ip address
(config-if)#exit	Exit interface mode
(config)# interface xe10	Enter interface mode for xe10
(config-if)#ip address 10.1.1.1/24	Configure ip address
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the OSPF process (100)
(config-router)# ospf router-id 3.3.3.3	Configure OSPF router-id
(config-router)#network 20.1.1.0/24 area 0	Advertise the network in Area 0
(config-router)#exit	Exit Router mode and return to Configure mode
(config)#router bgp 100	Define the routing process. The number 100 specifies the AS number of R1.
(config-router)# bgp router-id 3.3.3.3	Configure BGP router-id
(config-router)#neighbor PG peer-group	Create a peer group named PG
(config-router)#neighbor PG remote-as 100	Assign options to the peer group named PG
(config-router)#neighbor PG update-source lo	Assign options to the peer group named PG
(config-router)#neighbor 1.1.1.1 peer-group PG	Define neighbor 1.1.1.1 (R1) as a peer group member.
(config-router)#address-family l2vpn evpn	Enter address-family l2vpn evpn mode
(config-router-af)#neighbor PG activate	Activate the peer-group ABC for address-family l2vpn evpn
(config-router-af)# exit-address-family	Exit address-family ipv4 unicast mode

(config-router)#exit	Exit router bgp mode
(config)#commit	Commit the candidate configuration to the running configuration.

Validation

R1

```
R1#sh run bgp
!
router bgp 100
 bgp router-id 1.1.1.1
 neighbor PG peer-group
 neighbor PG remote-as 100
 neighbor PG update-source lo
 neighbor 2.2.2.2 peer-group PG
 neighbor 3.3.3.3 peer-group PG
 !
 address-family l2vpn evpn
 neighbor PG activate
 exit-address-family
R1#sh bgp neighbors
BGP neighbor is 2.2.2.2, remote AS 100, local AS 100, internal link
 Member of peer-group PG for session parameters
  BGP version 4, local router ID 1.1.1.1, remote router ID 2.2.2.2
  BGP state = Established, up for 01:20:53
  Last read 00:00:24, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family L2VPN EVPN: advertised and received
  Received 192 messages, 0 notifications, 0 in queue
  Sent 191 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
 For address family: L2VPN EVPN
  BGP table version 1, neighbor version 1
  Index 2, Offset 0, Mask 0x4
  PG peer-group member
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  0 accepted prefixes
  Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  0 announced prefixes

 Connections established 1; dropped 0
Local host: 1.1.1.1, Local port: 42981
Foreign host: 2.2.2.2, Foreign port: 179
```

```
Nexthop: 1.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

BGP neighbor is 3.3.3.3, remote AS 100, local AS 100, internal link
 Member of peer-group PG for session parameters
  BGP version 4, local router ID 1.1.1.1, remote router ID 3.3.3.3
  BGP state = Established, up for 01:36:13
  Last read 00:00:08, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family L2VPN EVPN: advertised and received
  Received 227 messages, 0 notifications, 0 in queue
  Sent 229 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
 For address family: L2VPN EVPN
  BGP table version 1, neighbor version 1
  Index 3, Offset 0, Mask 0x8
  PG peer-group member
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  0 accepted prefixes
  Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  0 announced prefixes

 Connections established 1; dropped 0
Local host: 1.1.1.1, Local port: 179
Foreign host: 3.3.3.3, Foreign port: 32857
Nexthop: 1.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
R1#sh ip ospf neighbor

Total number of full neighbors: 2
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/Backup     00:00:38   10.1.1.1       xe15                  0
3.3.3.3          1   Full/Backup     00:00:34   20.1.1.1       ce0                   0
R1#sh bgp l2vpn evpn summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 1
1 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
```

```
2.2.2.2             4   100  193       191      1      0      0  01:21:07
0      0      0      0      0      0
3.3.3.3             4   100  227       229      1      0      0  01:36:27
0      0      0      0      0      0

Total number of neighbors 2

Total number of Established sessions 2
```

R2

```
R2#sh run bgp
!
router bgp 100
 bgp router-id 2.2.2.2
 neighbor PG peer-group
 neighbor PG remote-as 100
 neighbor PG update-source lo
 neighbor 1.1.1.1 peer-group PG
  !
 address-family l2vpn evpn
 neighbor PG activate
 exit-address-family
!
R2#sh bgp neighbors
BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link
 Member of peer-group PG for session parameters
  BGP version 4, local router ID 2.2.2.2, remote router ID 1.1.1.1
  BGP state = Established, up for 01:20:42
  Last read 00:00:20, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family L2VPN EVPN: advertised and received
  Received 190 messages, 0 notifications, 0 in queue
  Sent 193 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
 For address family: L2VPN EVPN
  BGP table version 1, neighbor version 1
  Index 2, Offset 0, Mask 0x4
  PG peer-group member
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  0 accepted prefixes
  Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  0 announced prefixes

 Connections established 1; dropped 0
Local host: 2.2.2.2, Local port: 179
Foreign host: 1.1.1.1, Foreign port: 42981
```

```
Nexthop: 2.2.2.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

R2#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
1.1.1.1          1   Full/DR         00:00:30    10.1.1.2       xe10                  0
R2#sh bgp l2vpn evpn summary
BGP router identifier 2.2.2.2, local AS number 100
BGP table version is 1
0 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
1.1.1.1                4   100  192       195      1      0      0  01:21:28
0      0      0      0      0      0

Total number of neighbors 1

Total number of Established sessions 1
```

R3

```
R3#sh run bgp
!
router bgp 100
 bgp router-id 3.3.3.3
 neighbor PG peer-group
 neighbor PG remote-as 100
 neighbor PG update-source lo
 neighbor 1.1.1.1 peer-group PG
 !
 address-family l2vpn evpn
 neighbor PG activate
 exit-address-family
!
R3#sh bgp neighbors
BGP neighbor is 1.1.1.1, remote AS 100, local AS 100, internal link
 Member of peer-group PG for session parameters
  BGP version 4, local router ID 3.3.3.3, remote router ID 1.1.1.1
  BGP state = Established, up for 01:36:07
  Last read 00:00:06, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family L2VPN EVPN: advertised and received
```

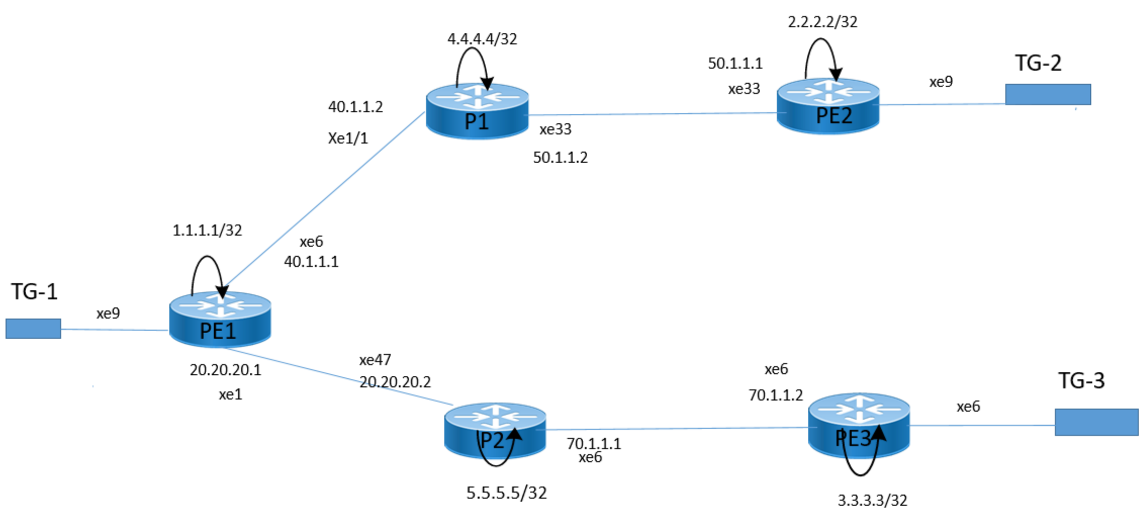
```
  Received 228 messages, 0 notifications, 0 in queue
  Sent 227 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo
 For address family: L2VPN EVPN
  BGP table version 1, neighbor version 1
  Index 2, Offset 0, Mask 0x4
  PG peer-group member
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  0 accepted prefixes
  Accepted AD:0 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  0 announced prefixes

 Connections established 1; dropped 0
Local host: 3.3.3.3, Local port: 32857
Foreign host: 1.1.1.1, Foreign port: 179
Nexthop: 3.3.3.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
R3#sh ip os neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
1.1.1.1          1   Full/DR         00:00:37   20.1.1.2       ce15                  0
R3#sh bgp l2vpn evpn summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 1
0 BGP AS-PATH entries
0 BGP community entries

Neighbor                V   AS   MsgRcv    MsgSen TblVer   InQ   OutQ    Up/Down   State/
PfxRcd     AD  MACIP  MCAST    ESI  PREFIX-ROUTE
1.1.1.1                4   100  232       231      1      0      0  01:37:55
0      0      0      0      0      0

Total number of neighbors 1

Total number of Established sessions 1
```

CHAPTER 19 Point-to-Point Connections Over MPLS

Overview

An MPLS Layer 2 Virtual Circuit (VC) facilitates efficient point-to-point Layer 2 connectivity in a service providers MPLS network. It enables Layer 2 circuit transport across the providers infrastructure, ensuring secure communication between remote sites through a single Label Switched Path (LSP) tunnel connecting Provider Edge (PE) routers. This feature optimizes network performance and supports diverse applications and services.

Topology



The VC configuration process can be divided into the following steps:

Note: Loopback addresses being used should be advertised through OSPF, or must be statically routed.

1. Configure the IP address and OSPF for the PE-1, P (Provider), and PE-2 routers.
2. Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peer for the PE-1 and PE-2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2.)
3. Configure the VC.
4. Bind the customer interface to the VC.

Configure IP Address and OSPF on Routers

Configure the IP addresses and OSPF on the PE-1, P1,P2, PE2 and PE-3 routers.

PE-1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to `1.1.1.1/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe6`	Specify the interface `(xe6)` to be configured.
`(config-if)#ip address 40.1.1.1/24`	Set the IP address of the interface to `40.1.1.1/24`
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 20.20.20.1/24`	Set the IP address of the interface to 20.20.20.1/24
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

`(config-router)#network 40.1.1.0/24 area 0`
`(config-router)#network 1.1.1.1/32 area 0`
`(config-router)# network 20.20.20.0/24 area 0`
	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface.

P1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 4.4.4.4/32 secondary`	Set the IP address of the loopback interface to `9.9.9.9/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1/1`	Specify the interface `(xe1/1)` to be configured.
`(config-if)#ip address 40.1.1.2/24`	Set the IP address of the interface to `40.1.1.2/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe33`	Specify the interface `(xe33)` to be configured.
`(config-if)#ip address 50.1.1.2/24`	Set the IP address of the interface to `50.1.1.1/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

`(config-router)#network  40.1.1.0/24  area  0`
`(config-router)#network  50.1.1.0/24  area  0`
`(config-router)#network 4.4.4.4/32 area 0`
	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface.

P2

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 5.5.5.5/32 secondary`	Set the IP address of the loopback interface to `5.5.5.5/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe6`	Specify the interface `(xe1/1)` to be configured.
`(config-if)#ip address 70.1.1.1/24`	Set the IP address of the interface to `70.1.1.1/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe47`	Specify the interface `(xe47)` to be configured.
`(config-if)#ip address 20.20.20.2/24`	Set the IP address of the interface to `20.20.20.2/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

`(config-router)#network 20.20.20.20/24 area 0`
`(config-router)#network  70.1.1.0/24  area  0`
`(config-router)#network 5.5.5.5/32 area 0`
	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface.

PE-2

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to `2.2.2.2/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe33`	Specify the interface `(xe33)` to be configured.
`(config-if)#ip address 50.1.1.1/24`	Set the IP address of the interface to 50.1.1.1/24
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 50.1.1.0/24 area 0` `(config-router)#network 2.2.2.2/32 area 0`	Define the interface on which OSPF runs, and associate the area ID `(0)` with the interface.

PE-3

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.

(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe6	Specify the interface (xe33) to be configured.
(config-if)#ip address 70.1.1.2/24	Set the IP address of the interface 70.1.1.2/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 70.1.1.0/24 area 0 (config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.

Configure MPLS, LDP, and LDP Targeted Peer on Routers

PE-1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 1.1.1.1	Configure LDP router ID.
(config-router)#pw-status-tlv	Set PW status TLV
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 2.2.2.2	Specify the targeted LDP peer on PE-1.
(config-router)#targeted-peer ipv4 3.3.3.3	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#label-switching	Enable label switching on interface xe6
(config-if)#enable-ldp ipv4	Enable LDP on interface xe6.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 2.2.2.2	Configure LDP router ID.
(config-router)#pw-status-tlv	Set PW status TLV

(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the `Router` mode.
(config)#interface xe33	Specify the interface `(xe33)` to be configured.
(config-if)#label-switching	Enable label switching on interface `xe1`.
(config-if)#enable-ldp ipv4	Enable LDP on interface `xe33`.

PE3

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the `Router` mode.
(config)# router-id 3.3.3.3	Configure LDP router ID.
(config-router)#pw-status-tlv	Set PW status TLV
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the `Router` mode.
(config)#interface xe6	Specify the interface `(xe6)` to be configured.
(config-if)#label-switching	Enable label switching on interface `xe6`.
(config-if)#enable-ldp ipv4	Enable LDP on interface `xe6`.

P1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the `Router` mode.
(config)# router-id 4.4.4.4	Configure LDP router ID.
(config-router)#exit	Exit the `Router` mode.
(config)#interface xe1/1	Specify the interface `(xe1/1)` to be configured.
(config-if)#label-switching	Enable label switching on interface `xe1/1`.
(config-if)#enable-ldp ipv4	Enable LDP on interface `xe1`.
(config)#interface xe33	Specify the interface `(xe6)` to be configured.
(config-if)#label-switching	Enable label switching on interface `xe33`.
(config-if)#enable-ldp ipv4	Enable LDP on interface `xe33`.

P2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)# router-id 5.5.5.5	Configure LDP router ID.
(config-router)#exit	Exit the Router mode.
(config)#interface xe6	Specify the interface (xe6) to be configured.
(config-if)#label-switching	Enable label switching on interface xe6.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config)#interface xe47	Specify the interface (xe47) to be configured.
(config-if)#label-switching	Enable label switching on interface xe47.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe47.

Configure VC

Configure the VC. Each VC ID uniquely identifies the Layer-2 circuit among all the Layer-2 circuits.

PE-1

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-100-1 10000100 3.3.3.3	Configure the VC for PE-3. In this example, VPLS-100-1 is the VC name, 10000100is the VC ID, and 3.3.3.3 is the VC endpoint IP address.
(config-pseudowire)# mpls l2-circuit VPLS-200-3 30000200 2.2.2.2	Configure the VC for PE-2. In this example, VPLS-200-3 is the VC name, 30000200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.

PE-2

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-200-3 30000200 1.1.1.1	Configure the VC for PE-1. In this example, VPLS-200-3 is the VC name, 30000200is the VC ID, and 1.1.1.1is the VC endpoint IP address.

PE-3

#configure terminal	Enter configure mode.
(config)# mpls l2-circuit VPLS-100-1 10000100 1.1.1.1 mode tagged	Configure the VC for PE-1. In this example, VPLS-100-1 is the VC name, 10000100is the VC ID, and 1.1.1.1is the VC endpoint IP address.

Bind Customer Interface to VC

PE-1

`#configure terminal`	Enter configure mode.
`(config)# mpls l2-circuit VPLS-100-1 10000100 3.3.3.3`	Configure the VC for PE-3. In this example, VPLS-100-1 is the VC name, 10000100is the VC ID, and 3.3.3.3 is the VC endpoint IP address.
`(config-pseudowire)# mpls l2-circuit VPLS-200-3 30000200 2.2.2.2`	Configure the VC for PE-2. In this example, VPLS-200-3 is the VC name, 30000200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#interface xe9.10 switchport`	Creates a L2 sub-interface as xe9.10
`(config-if)#encapsulation dot1q 10`	Configure the encapsulation as dot1q matching vlan 10
`(config-if)#access-if-vpws`	Configure access-if-vpws on interface mode
`(config-acc-if-vpws)#mpls-l2-circuit VPLS-200-3 primary`	Configure the VC for PE-1 In this example, VPLS-200-3 is the VC name
`(config-acc-if-vpws)#mpls-l2-circuit VPLS-100-1 secondary`	Configure the VC for PE-1 In this example, VPLS-200-3 is the VC name
`(config-acc-if-vpws)#vc-mode revertive`	Configured the vc-mode revertive

PE-2

`#configure terminal`	Enter configure mode.
`(config)# mpls l2-circuit VPLS-200-3 30000200 1.1.1.1`	Configure the VC for PE-1. In this example, VPLS-200-3 is the VC name, 30000200is the VC ID, and 1.1.1.1is the VC endpoint IP address.
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#interface xe9.10 switchport`	Creates a L2 sub-interface as xe9.10
`(config-if)#encapsulation dot1q 10`	Configure the encapsulation as dot1q matching vlan 10
`(config-if)#access-if-vpws`	Configure access-if-vpws on interface mode
`(config-acc-if-vpws)#mpls-l2-circuit VPLS-200-3 primary`	Configure the VC for PE-12 In this example, VPLS-200-3 is the VC name.

PE-3

`#configure terminal`	Enter configure mode.
`(config)# mpls l2-circuit VPLS-200-3 30000200 1.1.1.1`	Configure the VC for PE-1. In this example, VPLS-200-3 is the VC name, 30000200is the VC ID, and 1.1.1.1is the VC endpoint IP address.
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#interface xe6.100 switchport`	Creates a L2 sub-interface as xe6.100

(config-if)#encapsulation dot1q 100	Configure the encapsulation as dot1q matching vlan 100
(config-if)#access-if-vpws	Configure access-if-vpws on interface mode
(config-acc-if-vpws)# mpls-l2-circuit VPLS-100-1 primary	Configure the VC for PE-12 In this example, VPLS-100-1 is the VC name

Validation

```
   PE1#sh ldp session
      Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       2.2.2.2            xe6        Passive   OPERATIONAL   30    02:30:38
       3.3.3.3            xe1        Passive   OPERATIONAL   30    02:30:40
       5.5.5.5            xe1        Passive   OPERATIONAL   30    02:30:38
       4.4.4.4            xe6        Passive   OPERATIONAL   30    02:30:38
PE1#
PE1#sh ip ospf neighbor

Total number of full neighbors: 2
OSPF process 100 VRF(default):
Neighbor ID     Pri   State          Dead Time   Address        Interface
Instance ID
5.5.5.5          1   Full/DR       00:00:30   20.20.20.2     xe1
0
4.4.4.4          1   Full/Backup     00:00:36   40.1.1.2       xe6
```

```
0
PE1#
```

Use the show ldp mpls-l2-circuit (Control Plane) command, and the show mpls vc-table (Forwarding Plane) command, to display complete information about the Layer 2 VC.

If the VC State is UP in the output from the show ldp mpls-l2 circuit command, and the Status is Active in the output of the show mpls vc-table command, a ping from CE1 to CE2 should be successful.

```
PE1#show ldp mpls-l2-circuit
Transport     Client     VC     VC             Local       Remote      Destination
VC ID         Binding    State  Type           VC Label    VC Label    Address
30000200      xe9.10     UP     Ethernet VLAN  26881       26880       2.2.2.2
10000100      xe9.10     UP     Ethernet VLAN  26880       26880       3.3.3.3
PE1#
PE1#
PE1#sh mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-
Label  Nexthop         Status     UpTime
10000100    N/A      N/A           xe9.10        -             26880      N/A
3.3.3.3         Inactive    -
30000200    N/A      N/A           xe9.10        xe6           26880      52480
2.2.2.2         Active     02:35:05
PE1#
PE1#
```

```
PE2#sh ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
```

```
       Session has to be cleared manually


Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       1.1.1.1            xe33       Active    OPERATIONAL   30    02:37:16
       4.4.4.4            xe33       Passive   OPERATIONAL   30    02:43:19
PE2#
PE2#
PE2#sh ip ospf neighbor


Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State           Dead Time   Address        Interface
Instance ID
4.4.4.4          1   Full/DR         00:00:38   50.1.1.2       xe33                  0
PE2#
PE2#
PE2#
PE2#sh mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP


VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-
Label  Nexthop         Status     UpTime
30000200   N/A     N/A           xe9.10       xe33         26881     52481
1.1.1.1         Active     02:37:30
PE2#
PE2#
PE2#


PE3#sh ldp session
Codes: m - MD5 password is not set/unset.
```

```
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       1.1.1.1            xe6        Active    OPERATIONAL   30    02:38:00
       5.5.5.5            xe6        Passive   OPERATIONAL   30    02:43:52
PE3#
PE3#
PE3#sh ip ospf neii
PE3#sh ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State           Dead Time   Address        Interface
Instance ID
5.5.5.5           1   Full/DR         00:00:36    70.1.1.1       xe6                   0
PE3#
PE3#
PE3#
PE3#sh mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-
Label  Nexthop         Status     UpTime
10000100    N/A      N/A           xe6.100      -            26880     N/A
1.1.1.1         Inactive    -
PE3#
PE3#
P1#sh ip ospf neighbor
```

```
Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID

1.1.1.1           1   Full/DR         00:00:32    40.1.1.1        xe1/1                 0

2.2.2.2           1   Full/Backup     00:00:31    50.1.1.1        xe33                  0

P1#

P1#

P1#s

% Incomplete command.


P1#

P1#sh ldp session

Codes: m - MD5 password is not set/unset.

       g - GR configuration not set/unset.

       t - TCP MSS not set/unset.

       Session has to be cleared manually


Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime

       1.1.1.1            xe1/1      Active    OPERATIONAL   30    02:40:25

       2.2.2.2            xe33       Active    OPERATIONAL   30    02:46:28

P1#

P2#sh ldp session

Codes: m - MD5 password is not set/unset.

       g - GR configuration not set/unset.

       t - TCP MSS not set/unset.

       Session has to be cleared manually


Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime

       1.1.1.1            xe47       Active    OPERATIONAL   30    02:40:56
```

```
       3.3.3.3            xe6        Active    OPERATIONAL   30    02:46:49

P2#

P2#sh ip ospf neighbor


Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID

1.1.1.1           1   Full/Backup     00:00:35    20.20.20.1      xe47                 0

3.3.3.3           1   Full/Backup     00:00:32    70.1.1.2        xe6                  0

P2#(config-if)#mpls-l2-circuit t2 service- template ST1
```

CHAPTER 20 Deep Packet Inspection

Overview

Deep Packet Inspection (DPI) performs a granular check on the inner headers beyond the MPLS bottom of the label stack (BOS) to load-balance the network traffic. The load balancing key is generated after deep analysis of the MPLS header.

The DPI can be configured in the Qumran1 series platforms, and a system reboot is required after enabling and disabling the feature. In Qumran2 series platforms, it is always enabled by default.

Benefits

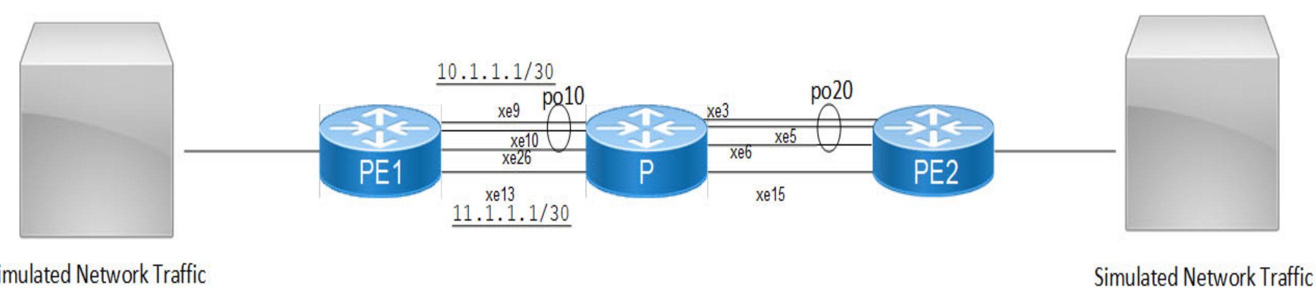
The DPI feature optimizes network performance by preventing traffic congestion by distributing traffic across available pathways.

Configuration

This section shows the configuration of the DPI.

Topology

In this topology, the traffic flows from one Provider Edge (PE1) to another Provider Edge router (PE2) through a transit Provider router (P). From P to PE2, there is a Link Aggregation Group (LAG) consisting of `xe3`, `xe5`, and `xe6` and a physical interface connection through `xe15`. When DPI is enabled, the traffic is load-balanced through the ECMP next-hops `po` and (`xe15`) and also among the LAG member ports (`xe3`, `xe5`, and `xe6`).



T

Figure 20-10: DPI Configuration

Configuring DPI

Follow the steps to configure the DPI on Qumran1 series platforms.

PE1

1. Configure IP address secondary on loopback.

```
(config)#interface lo
(config-if)#ip address 3.3.3.3/32 secondary
```

2. Configure prefix SID on the loopback interface to add the prefix SID global block to forward the packet.

```
(config)#interface lo
(config-if)#prefix-sid index 3 no-php
```

3. Configure the ISIS on the node with some paths having the Link Aggregation Group (LAG) member port. This allows the DPI feature to run on the LAG member ports.

```
(config)#interface po10
(config-if)#load-interval 30
(config-if)#ip address 10.1.1.1/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
(config-if)#exit
(config)#interface xe9
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe10
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe26
(config-if)#channel-group 10 mode active
(config-if)#exit
```

4. Configure the ISIS on the physical interface.

```
(config)#interface xe13
(config-if)#load-interval 30
(config-if)#ip address 11.1.1.1/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
```

5. Configure router ISIS on the loopback interface to advertise it.

```
(config-if)#interface lo
(config-if)#ip router isis 1
(config-if)#exit
```

6. Configure the router ISIS sessions to establish the neighborship between the routers.

```
(config)#router isis 1
(config-router)#is-type level-1-2
(config-router)#metric-style wide
(config-router)#mpls traffic-eng router-id 3.3.3.3
(config-router)#mpls traffic-eng level-1
(config-router)#mpls traffic-eng level-2
(config-router)#capability cspf
(config-router)#bfd all-interfaces
(config-router)#net 49.0001.0000.0001.0003.00
(config-router)#passive-interface lo
```

7. Enable the Segment Routing (SR), SR entropy, and Topology Independent Loop Free Alternate (TILFA).

```
(config)#router isis 1
(config-router)#fast-reroute ti-lfa level-1 proto ipv4
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#isis segment-routing global block 20000 23000
(config-router)#segment-routing entropy-label
(config-router)#segment-routing mpls
```

8. Configure any of the MPLS services. In this configuration, we are configuring L3VPN service.

```
(config)#ip vrf 1001
(config-vrf)#rd 3.3.3.3:1001
(config-vrf)#route-target both 1001:1001
(config-vrf)#exit
(config)#interface xe6.1001
(config-if)#encapsulation dot1q 1001
(config-if)#load-interval 30
(config-if)#ip vrf forwarding 1001
(config-if)#ip address 201.1.1.1/24
(config-if)#ipv6 address 201::1/64
(config-if)#mtu 9216
(config-if)#exit
(config)#router bgp 65010
(config-router)#bgp router-id 3.3.3.3
(config-router)#neighbor 6.6.6.6 remote-as 65010
(config-router)#neighbor 6.6.6.6 update-source lo
(config-router)#address-family vpnv4 unicast
(config-router-af)#neighbor 6.6.6.6 activate
(config-router-af)#exit-address-family
(config-router)# address-family vpnv6 unicast
(config-router-af)#neighbor 6.6.6.6 activate
(config-router-af)exit-address-family
(config-router)#address-family ipv4 vrf 1001
(config-router-af)redistribute connected
(config-router-af)neighbor 201.1.1.2 remote-as 65011
(config-router-af)neighbor 201.1.1.2 activate
(config-router-af)exit-address-family
(config-router)#address-family ipv6 vrf 1001
(config-router-af)#redistribute connected
(config-router-af)#neighbor 201::2 remote-as 65011
(config-router-af)#neighbor 201::2 activate
(config-router-af)#exit-address-family
```

9. Enable the SR Equi-Cost-Multiple-Path (ECMP) Forwarding Table Notification (FTN) to load-balance the traffic within the LAG and physical ports.

```
(config)#mpls ftn-ecmp sr
```

10. Enable the DPI on Qumran1 series platforms.

```
(config)#advanced parser enable
```

Note: DPI is enabled by default on Qumran2 series platforms.

P

1. Configure IP address secondary on the loopback.

```
P(config)#interface lo
(config-if)#ip address 2.2.2.2/32 secondary
```

2. Configure prefix SID on the loopback interface to add the prefix SID global block to forward the packet.

```
(config)#interface lo
(config-if)#prefix-sid index 2 no-php
```

3. Configure the ISIS on the node with some paths having the Link Aggregation Group (LAG) member port. This allows the DPI feature to run on the LAG member ports.

```
(config)#interface po10
(config-if)#load-interval 30
(config-if)#ip address 10.1.1.2/30
```

```
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
(config-if)#exit
(config)#interface xe9
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe10
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe26
(config-if)#channel-group 10 mode active
(config-if)#exit
```

4. Configure the ISIS on the physical interface.

```
(config)#interface xe13
(config-if)#load-interval 30
(config-if)#ip address 11.1.1.2/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 50
```

5. Configure router ISIS on the loopback interface to advertise it.

```
(config-if)#interface lo
(config-if)#ip router isis 1
(config-if)#exit
```

6. Configure the router ISIS sessions to establish the neighborship between the routers.

```
(config)#router isis 1
(config-router)#is-type level-1-2
(config-router)#metric-style wide
(config-router)#mpls traffic-eng router-id 2.2.2.2
(config-router)#mpls traffic-eng level-1
(config-router)#mpls traffic-eng level-2
(config-router)#capability cspf
(config-router)#bfd all-interfaces
(config-router)#net 49.0001.0000.0001.0002.00
(config-router)#passive-interface lo
```

7. Enable the SR, SR entropy, and TILFA.

```
(config)#router isis 1
(config-router)#fast-reroute ti-lfa level-1 proto ipv4
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#isis segment-routing global block 20000 23000
(config-router)#segment-routing entropy-label
(config-router)#segment-routing mpls
```

8. Enable the SR ECMP Incoming Label Map (ILM).

```
(config)#mpls ilm-ecmp sr
```

9. Enable the DPI on Qumran1 series platforms.

```
(config)#advanced parser enable
```

Note: DPI is enabled by default on Qumran2 series platforms.

PE2

1. Configure IP address secondary on the loopback interface
```
(config)#interface lo
(config-if)#ip address 6.6.6.6/32 secondary
```
2. Configure prefix SID on the loopback interface to add the prefix SID global block to forward the packet.
```
(config)#interface lo
(config-if)#prefix-sid index 6 no-php
```
3. Configure the ISIS on the node with some paths having the Link Aggregation Group (LAG) member port. This allows the DPI feature to run on the LAG member ports.
```
(config)#interface po20
(config-if)#load-interval 30
(config-if)#ip address 12.1.1.2/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 100
(config-if)#exit
(config)#interface xe3
 (config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe5
(config-if)#channel-group 10 mode active
(config-if)#exit
(config)#interface xe6
(config-if)#channel-group 10 mode active
(config-if)#exit
```
4. Configure the ISIS on the physical interface.
```
(config)#interface xe15
(config-if)#load-interval 30
(config-if)#ip address 13.1.1.2/30
(config-if)#mtu 9216
(config-if)# label-switching
(config-if)#ip router isis 1
(config-if)#isis wide-metric 100
```
5. Configure router ISIS on the loopback interface to advertise it.
```
(config-if)#interface lo
(config-if)#ip router isis 1
(config-if)#exit
```
6. Configure the router ISIS sessions to establish the neighborship between the routers.
```
(config)#router isis 1
(config-router)#is-type level-1-2
(config-router)#metric-style wide
(config-router)#mpls traffic-eng router-id 6.6.6.6
(config-router)#mpls traffic-eng level-1
(config-router)#mpls traffic-eng level-2
(config-router)#capability cspf
(config-router)#bfd all-interfaces
(config-router)#net 49.0001.0000.0001.0006.00
(config-router)#passive-interface lo
```
7. Enable the SR, SR entropy, and TILFA.
```
(config)#router isis 1
```

```
(config-router)#fast-reroute ti-lfa level-1 proto ipv4
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#isis segment-routing global block 20000 23000
(config-router)#segment-routing entropy-label
(config-router)#segment-routing mpls
```

8. Configure any of the MPLS services. In this configuration, we are configuring L3VPN service.

```
(config)#ip vrf 1001
(config-vrf)#rd 6.6.6.6:1001
(config-vrf)#route-target both 1001:1001
(config-vrf)#exit
(config)#interface xe2.1001
(config-if)#encapsulation dot1q 1001
(config-if)#load-interval 30
(config-if)#ip vrf forwarding 1001
(config-if)#ip address 101.1.1.1/24
(config-if)#ipv6 address 101::1/64
(config-if)#mtu 9216
(config-if)#exit
(config)#router bgp 65010
(config-router)#bgp router-id 6.6.6.6
(config-router)#neighbor 3.3.3.3 remote-as 65010
(config-router)#neighbor 3.3.3.3 update-source lo
(config-router)#address-family vpnv4 unicast
(config-router-af)#neighbor 3.3.3.3 activate
(config-router-af)#exit-address-family
(config-router)#address-family vpnv6 unicast
(config-router-af)#neighbor 3.3.3.3 activate
(config-router-af)#exit-address-family
(config-router)#address-family ipv4 vrf 1001
(config-router-af)#redistribute connected
(config-router-af)#neighbor 101.1.1.2 remote-as 65011
(config-router-af)#neighbor 101.1.1.2 activate
(config-router-af)#exit-address-family
(config-router)# address-family ipv6 vrf 1001
(config-router-af)#redistribute connected
(config-router-af)#neighbor 101::2 remote-as 65011
(config-router-af)#neighbor 101::2 activate
(config-router-af)#exit-address-family
```

9. Enable the SR ECMP FTN to load-balance the traffic within the LAG and physical ports.

```
(config)#mpls ftn-ecmp sr
```

10. Enable the DPI on Qumran1 series platforms.

```
(config)#advanced parser enable
```

Note: DPI is enabled by default on Qumran2 series platforms.

Running configurations

The running configuration for the PE1 is as follows:

```
#show running-config
!
mpls ftn-ecmp sr
!
ip vrf 1001
```

```
 rd 3.3.3.3:1001
 route-target both 1001:1001
!
interface po10
 load-interval 30
 ip address 10.1.1.1/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 50
!
interface lo
 ip address 127.0.0.1/8
 ip address 3.3.3.3/32 secondary
 ipv6 address ::1/128
 prefix-sid index 3 no-php
!
interface xe6.1001
 encapsulation dot1q 1001
 load-interval 30
 ip vrf forwarding 1001
 ip address 201.1.1.1/24
 ipv6 address 201::1/64
 mtu 9216
!
interface xe9
 channel-group 10 mode active
!
interface xe10
 channel-group 10 mode active
!
interface xe13
 load-interval 30
 ip address 11.1.1.1/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 50
!
interface xe26
 channel-group 10 mode active
!
router isis 1
 is-type level-1-2
 metric-style wide
 mpls traffic-eng router-id 3.3.3.3
 mpls traffic-eng level-1
 mpls traffic-eng level-2
 capability cspf
 fast-reroute ti-lfa level-1 proto ipv4
 fast-reroute ti-lfa level-2 proto ipv4
 bfd all-interfaces
 net 49.0001.0000.0001.0003.00
 passive-interface lo
 isis segment-routing global block 20000 23000
 segment-routing entropy-label
 segment-routing mpls
```

```
!
router bgp 65010
 bgp router-id 3.3.3.3
 neighbor 6.6.6.6 remote-as 65010
 neighbor 6.6.6.6 update-source lo
 !
 address-family vpnv4 unicast
 neighbor 6.6.6.6 activate
 exit-address-family
 !
 address-family vpnv6 unicast
 neighbor 6.6.6.6 activate
 exit-address-family
 !
 address-family ipv4 vrf 1001
 redistribute connected
 neighbor 201.1.1.2 remote-as 65011
 neighbor 201.1.1.2 activate
 exit-address-family
 !
 address-family ipv6 vrf 1001
 redistribute connected
 neighbor 201::2 remote-as 65011
 neighbor 201::2 activate
 exit-address-family
```

The running configuration for the P is as follows:

```
advanced parser enable
!
mpls ilm-ecmp sr
!
interface po10
 load-interval 30
 ip address 10.1.1.2/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 50
!
interface po20
 load-interval 30
 ip address 12.1.1.1/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 100
!
interface lo
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128
 prefix-sid index 2 no-php
 ip router isis 1
!
interface xe3
 channel-group 20 mode active
```

```
!
interface xe5
 channel-group 20 mode active
!
interface xe6
 channel-group 20 mode active
!
interface xe9
 channel-group 10 mode active
!
interface xe10
 channel-group 10 mode active
!
interface xe13
 load-interval 30
 ip address 11.1.1.2/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 50
!
interface xe15
 load-interval 30
 ip address 13.1.1.1/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 100
!
interface xe26
 channel-group 10 mode active
!
router isis 1
 is-type level-1-2
 metric-style wide
 mpls traffic-eng router-id 2.2.2.2
 mpls traffic-eng level-1
 mpls traffic-eng level-2
 capability cspf
 fast-reroute ti-lfa level-1 proto ipv4
 fast-reroute ti-lfa level-2 proto ipv4
 bfd all-interfaces
 net 49.0001.0000.0001.0002.00
 passive-interface lo
 isis segment-routing global block 20000 23000
 segment-routing entropy-label
 segment-routing mpls
```

The running configuration for the PE2 is as follows:

```
mpls ftn-ecmp sr
!
ip vrf 1001
 rd 6.6.6.6:1001
 route-target both 1001:1001
!
interface po20
 load-interval 30
```

```
 ip address 12.1.1.2/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 100
!
interface lo
 ip address 127.0.0.1/8
 ip address 6.6.6.6/32 secondary
 ipv6 address ::1/128
 prefix-sid index 6 no-php
 ip router isis 1
!
interface xe2.1001
 encapsulation dot1q 1001
 load-interval 30
 ip vrf forwarding 1001
 ip address 101.1.1.1/24
 ipv6 address 101::1/64
 mtu 9216
!
interface xe3
 channel-group 20 mode active
!
interface xe5
 channel-group 20 mode active
!
interface xe6
 channel-group 20 mode active
!
interface xe15
 load-interval 30
 ip address 13.1.1.2/30
 mtu 9216
 label-switching
 ip router isis 1
 isis wide-metric 100
!
router isis 1
 is-type level-1-2
 metric-style wide
 mpls traffic-eng router-id 6.6.6.6
 mpls traffic-eng level-1
 mpls traffic-eng level-2
 capability cspf
 fast-reroute ti-lfa level-1 proto ipv4
 fast-reroute ti-lfa level-2 proto ipv4
 bfd all-interfaces
 net 49.0001.0000.0001.0006.00
 passive-interface lo
 isis segment-routing global block 20000 23000
 segment-routing entropy-label
 segment-routing mpls
!
router bgp 65010
 bgp router-id 6.6.6.6
 neighbor 3.3.3.3 remote-as 65010
```

```
neighbor 3.3.3.3 update-source lo
!
address-family vpnv4 unicast
neighbor 3.3.3.3 activate
exit-address-family
!
address-family vpnv6 unicast
neighbor 3.3.3.3 activate
exit-address-family
!
address-family ipv4 vrf 1001
redistribute connected
neighbor 101.1.1.2 remote-as 65011
neighbor 101.1.1.2 activate
exit-address-family
!
address-family ipv6 vrf 1001
redistribute connected
neighbor 101::2 remote-as 65011
neighbor 101::2 activate
exit-address-family
!
```

Validation

Validate the show output after configuration as shown below.

PE1

```
OcNOS#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
0000.0001.0002 xe13        80a2.35ec.d66f      Up     26        L1   IS-IS
                                               Up     26        L2   IS-IS
0000.0001.0002 po10        80a2.35ec.d699      Up     20        L1   IS-IS
                                               Up     20        L2   IS-IS

PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

ILM-ECMP LDP: Disabled, SR: Disabled
Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF       Nexthop              pri  UpTime
   i>   3.3.3.3/32        5           20003       Nolabel     N/A        N/A              127.0.0.1            Yes  00:06:41
   i>   2.2.2.2/32        2           20002       20002       N/A        xe13             11.1.1.2             Yes  00:00:47
                                       20002       3           N/A        po10             10.1.1.2             No   -
                                       20002       20002       N/A        po10             10.1.1.2             Yes  -
                                       20002       3           N/A        xe13             11.1.1.2             No   -
   i>   11.1.1.2/32       1           25600       3           N/A        xe13             11.1.1.2             Yes  00:00:47
                                       25600       20002       N/A        po10             10.1.1.2             No   -
   i>   6.6.6.6/32        3           20006       20006       N/A        xe13             11.1.1.2             Yes  00:00:47
                                       20006       20006       N/A        po10             10.1.1.2             No   -
                                       20006       20006       N/A        po10             10.1.1.2             Yes  -
                                       20006       20006       N/A        xe13             11.1.1.2             No   -
```

```
  i>   10.1.1.2/32       4          25601      3          N/A       po10           10.1.1.2              Yes  00:00:44
                                     25601      20002      N/A       xe13            11.1.1.2              No   -

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:07:47, UpTime: 00:07:47, LastUpdate: 00:07:34
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 2 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe13, out label: 20002
    Nexthop addr: 11.1.1.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 19  bypass ftn-ix: 4
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 19, owner: N/A, Stale: NO, refcount: 4, out intf: po10, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 1, op code: Push

     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 3, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po10, out label: 20002
    Nexthop addr: 10.1.1.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 2, in intf: - in label: 0  out-segment ix: 17  bypass ftn-ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 17, owner: N/A, Stale: NO, refcount: 4, out intf: xe13, out label: 3
    Nexthop addr: 11.1.1.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:07:39, UpTime: 00:07:39, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 2 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe13, out label: 20002
    Nexthop addr: 11.1.1.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:07:39, UpTime: 00:07:39, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 3, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po10, out label: 20002
    Nexthop addr: 10.1.1.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 6.6.6.6/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:07:47, UpTime: 00:07:47, LastUpdate: 00:07:34
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 21 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 21, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe13, out label: 20006
    Nexthop addr: 11.1.1.2        cross connect ix: 3, op code: Push

     Backup Cross connect ix: 5, in intf: - in label: 0  out-segment ix: 9  bypass ftn-ix: 4
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 9, owner: ISIS-SR, Stale: NO, refcount: 8, out intf: po10, out label: 20006
    Nexthop addr: 10.1.1.2        cross connect ix: 3, op code: Push

     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 9 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
      State: Active
       Out-segment with ix: 9, owner: ISIS-SR, Stale: NO, refcount: 8, out intf: po10, out label: 20006
    Nexthop addr: 10.1.1.2        cross connect ix: 3, op code: Push

     Backup Cross connect ix: 6, in intf: - in label: 0  out-segment ix: 21  bypass ftn-ix: 3
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 21, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe13, out label: 20006
    Nexthop addr: 11.1.1.2        cross connect ix: 3, op code: Push


PE1#
PE1#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup, B - BGP FTN
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP or SR ECMP

Code    FEC                 FTN-ID VRF-ID    Nhlfe-ID    Pri   Out-Label    Out-Intf         Nexthop         UpTime
   B>   101.1.1.0/24        2         2      4           Yes   25600        -                6.6.6.6         00:02:07
   B>   101::/64            1         2      4           Yes   25600        -                6.6.6.6         00:02:07
PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 2 (fib_id: 2)
 Primary FTN entry with FEC: 101.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:02:12, UpTime: 00:02:12, LastUpdate: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  VRF id 2, FIB id 2, BGP peer 6.6.6.6 BGP prefix 101.1.1.0
  Transport Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 4 refcount: 2
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: BGP, Stale: NO, refcount: 1, BGP out intf: xe13, transport out intf: xe13, out label:
25600
    Nexthop addr: 6.6.6.6        cross connect ix: 7, op code: Push and Lookup


Output for IPv6 VRF table with id: 2 (fib_id: 2)
 Primary FTN entry with FEC: 101::/64, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:02:12, UpTime: 00:02:12, LastUpdate: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  VRF id 2, FIB id 2, BGP peer 606:606:: BGP prefix 101::
  Transport Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 4 refcount: 2
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: BGP, Stale: NO, refcount: 1, BGP out intf: xe13, transport out intf: xe13, out label:
25600
    Nexthop addr: 6.6.6.6        cross connect ix: 7, op code: Push and Lookup
PE1#show etherchannel summary
  Aggregator po10 100010
  Aggregator Type: Layer3
  Admin Key: 0010 - Oper Key 0010
     Link: xe9 (10030) sync: 1
     Link: xe10 (10031) sync: 1
     Link: xe26 (10047) sync: 1
PE1#show int counters rate mbps
+-------------------+--------------+-------------+-------------+---------
----+
|    Interface    |   Rx mbps   |   Rx pps   |   Tx mbps   |   Tx pp
s   |
+-------------------+--------------+-------------+-------------+---------
----+
 po10             46.72       4146       93.44       8279
 xe6              42.79       3820       19.62       1751
 xe6.1001          200.52       17892       91.88       8203
 xe9              16.12       1430       28.98       2566
 xe10             15.13       1343       29.60       2623
 xe13             44.09       3906       87.51       7747
 xe26                 15.47          1372          34.86          3089
```

P

```
OcNOS#show clns neighbors
```

```
Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
0000.0001.0003 xe13        e8c5.7a11.9e64      Up     7         L1   IS-IS
                                               Up     7         L2   IS-IS
0000.0001.0006 xe15        e8c5.7a8b.5146      Up     8         L1   IS-IS
                                               Up     8         L2   IS-IS
0000.0001.0003 po10        e8c5.7a11.9e73      Up     8         L1   IS-IS
                                               Up     8         L2   IS-IS
0000.0001.0006 po20        e8c5.7a8b.5155      Up     7         L1   IS-IS
                                               Up     7         L2   IS-IS
P#
P#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

ILM-ECMP LDP: Disabled, SR: Enabled
Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF       Nexthop                 pri  UpTime
   i>   11.1.1.1/32       2           25600       3           N/A        xe13              11.1.1.1                Yes  00:01:19
                                       25600       20003       N/A        po10              10.1.1.1                No   -
   i>   3.3.3.3/32        6           20003       20003       N/A        po10              10.1.1.1                Yes  00:01:04
                                       20003       3           N/A        xe13              11.1.1.1                No   -
                                       20003       20003       N/A        xe13              11.1.1.1                Yes  -
                                       20003       3           N/A        po10              10.1.1.1                No   -
   i>   2.2.2.2/32        1           20002       Nolabel     N/A        N/A               127.0.0.1               Yes  00:01:40
   i>   6.6.6.6/32        7           20006       20006       N/A        po20              12.1.1.2                Yes  00:01:04
                                       20006       3           N/A        xe15              13.1.1.2                No   -
                                       20006       20006       N/A        xe15              13.1.1.2                Yes  -
                                       20006       3           N/A        po20              12.1.1.2                No   -
   i>   12.1.1.2/32       4           25602       3           N/A        po20              12.1.1.2                Yes  00:01:17
                                       25602       20006       N/A        xe15              13.1.1.2                No   -
   i>   13.1.1.2/32       3           25601       3           N/A        xe15              13.1.1.2                Yes  00:01:18
                                       25601       20006       N/A        po20              12.1.1.2                No   -
   i>   10.1.1.1/32       5           25603       3           N/A        po10              10.1.1.1                Yes  00:01:16
                                       25603       20003       N/A        xe13              11.1.1.1                No   -
P#show etherchannel summary
  Aggregator po10 100010
  Aggregator Type: Layer3
  Admin Key: 0010 - Oper Key 0010
     Link: xe9 (10009) sync: 1
     Link: xe10 (10010) sync: 1
     Link: xe26 (10026) sync: 1
--------------------------------------
  Aggregator po20 100020
  Aggregator Type: Layer3
  Admin Key: 0020 - Oper Key 0020
     Link: xe3 (10003) sync: 1
     Link: xe5 (10005) sync: 1
     Link: xe6 (10006) sync: 1
P#show int counters rate mbps
+-------------------+--------------+-------------+-------------+---------
----+
|    Interface    |  Rx mbps  |   Rx pps   |   Tx mbps  |   Tx pp
s   |
+-------------------+--------------+-------------+-------------+---------
----+
 po10            95.23       8438       47.61       4225
 po20            45.30       4018       89.16       7903
 xe3             12.12       1073       31.17       2762
 xe5             13.75       1220       29.17       2585
 xe6             19.44       1725       28.82       2555
 xe9             29.54       2615       16.42       1457
 xe10            30.16       2673       15.42       1369
 xe13            89.18       7895       44.93       3980
 xe15            47.31       4188       95.18       8428
 xe26                35.52          3148          15.77          1398
```

PE2

```
OcNOS#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled, SR: Enabled
Code    FEC              FTN-ID    Nhlfe-ID  Tunnel-ID   Pri   Out-Label    Out-Intf    ELC       Nexthop          UpTime
   i>   2.2.2.2/32       1         51        -           (e)   -            -           -         -                00:01:40
                                   1         0           Yes   20002        xe15        Yes       13.1.1.1         -
                                   4         -           No    3            po20        Yes       12.1.1.1         -
                                   2         0           Yes   20002        po20        Yes       12.1.1.1         -
                                   3         -           No    3            xe15        Yes       13.1.1.1         -
i(b)>   2.2.2.2/32       3         2         2201        Yes   20002        po20        No        12.1.1.1         00:01:38
i(b)>   2.2.2.2/32       4         1         2202        Yes   20002        xe15        No        13.1.1.1         00:01:38
   i>   3.3.3.3/32       2         53        -           (e)   -            -           -         -                00:01:40
                                   16        0           Yes   20003        xe15        Yes       13.1.1.1         -
                                   17        -           No    20003        po20        Yes       12.1.1.1         -
                                   17        0           Yes   20003        po20        Yes       12.1.1.1         -
                                   16        -           No    20003        xe15        Yes       13.1.1.1         -
PE2#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:08:00, UpTime: 00:08:00, LastUpdate: 00:07:39
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 1 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 1, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe15, out label: 20002
    Nexthop addr: 13.1.1.1        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 4  bypass ftn-ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 4, owner: N/A, Stale: NO, refcount: 4, out intf: po20, out label: 3
    Nexthop addr: 12.1.1.1        cross connect ix: 3, op code: Push

     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 2 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po20, out label: 20002
    Nexthop addr: 12.1.1.1        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 4, in intf: - in label: 0  out-segment ix: 3  bypass ftn-ix: 4
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 3, owner: N/A, Stale: NO, refcount: 4, out intf: xe15, out label: 3
    Nexthop addr: 13.1.1.1        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:07:58, UpTime: 00:07:58, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2201, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 2 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 2, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: po20, out label: 20002
    Nexthop addr: 12.1.1.1        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 4, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:07:58, UpTime: 00:07:58, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 2202, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, , Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 1 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 1, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: xe15, out label: 20002
```

```
    Nexthop addr: 13.1.1.1        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:08:00, UpTime: 00:08:00, LastUpdate: 00:07:39
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 16 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe15, out label: 20003
    Nexthop addr: 13.1.1.1        cross connect ix: 7, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 17  bypass ftn-ix: 3
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: po20, out label: 20003
    Nexthop addr: 12.1.1.1        cross connect ix: 7, op code: Push

     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 17 refcount: 1
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: po20, out label: 20003
    Nexthop addr: 12.1.1.1        cross connect ix: 7, op code: Push

     Backup Cross connect ix: 8, in intf: - in label: 0  out-segment ix: 16  bypass ftn-ix: 4
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      State: Active
       Out-segment with ix: 16, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe15, out label: 20003
    Nexthop addr: 13.1.1.1        cross connect ix: 7, op code: Push
PE2#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup, B - BGP FTN
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP or SR ECMP

Code    FEC                 FTN-ID VRF-ID    Nhlfe-ID    Pri   Out-Label    Out-Intf         Nexthop         UpTime
   B>   201.1.1.0/24        2         2      7           Yes   26240        -                3.3.3.3         00:01:07
   B>   201::/64            1         2      7           Yes   26240        -                3.3.3.3         00:01:07
PE2#show mpls vrf-table
Output for IPv4 VRF table with id: 2 (fib_id: 2)
 Primary FTN entry with FEC: 201.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:02:23, UpTime: 00:02:23, LastUpdate: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  VRF id 2, FIB id 2, BGP peer 3.3.3.3 BGP prefix 201.1.1.0
  Transport Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 7 refcount: 2
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: BGP, Stale: NO, refcount: 1, BGP out intf: xe15, transport out intf: xe15, out label: 
26240
    Nexthop addr: 3.3.3.3        cross connect ix: 9, op code: Push and Lookup


Output for IPv6 VRF table with id: 2 (fib_id: 2)
 Primary FTN entry with FEC: 201::/64, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed
  CreateTime: 00:02:23, UpTime: 00:02:23, LastUpdate: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  VRF id 2, FIB id 2, BGP peer 303:303:: BGP prefix 201::
  Transport Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
     Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 7 refcount: 2
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: BGP, Stale: NO, refcount: 1, BGP out intf: xe15, transport out intf: xe15, out label: 
26240
    Nexthop addr: 3.3.3.3        cross connect ix: 9, op code: Push and Lookup
PE2#show etherchannel summary
  Aggregator po20 100020
  Aggregator Type: Layer3
  Admin Key: 0020 - Oper Key 0020
     Link: xe3 (10010) sync: 1
     Link: xe5 (10012) sync: 1
     Link: xe6 (10013) sync: 1
PE2#show int counters rate mbps
+-------------------+-------------+------------+-------------+---------
----+
```

```
|    Interface    |   Rx mbps  |   Rx pps   |   Tx mbps  |   Tx pp
s   |
+-----------------+------------+------------+------------+---------
----+
 po20             87.50       7757        44.46       3944
 xe2              42.81       3822        39.18       3498
 xe2.1001          201.01      17885       183.04      16342
 xe3              30.59       2711        11.89       1053
 xe5              28.63       2537        13.49       1198
 xe6              28.29       2508        19.08       1693
 xe15       93.41     8272     46.42     4110
```

DPI Command

The DPI feature introduces the following configuration command.

advanced parser enable

Use this command to enable the DPI on Qumran1 series platforms.

Command Syntax

```
advanced parser enable
```

Parameters

None

Default

None

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 6.5.3 and applicable to Qumran1 series platforms.

Example

This example shows how to enable the DPI on Qumran1 series platforms:

```
OcNOS#configure terminal
OcNOS#(config)#advanced parser enable
OcNOS#(config)#commit
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
ECMP	Equal-Cost-Multiple-Path (ECMP) is a network routing technique that uses multiple paths when the paths have equal cost for packet transfer.
FTN	FEC to NHLFE Map is a networking concept that maps the incoming packet to the relevant routing path using the forwarding table.
ILM	Incoming Label Map (ILM) is a networking concept that checks the incoming packet labels and identifies the appropriate outgoing labels for the next hop.
ISIS	Intermediate System to Intermediate System (IS-IS) is an Interior Gateway Protocol used in computer networks to route data within an autonomous system.
LAG	Link Aggregation Group (LAG) is a collection of multiple network connections into a single logical link. This networking technique enhances bandwidth, provides redundancy, and improves fault tolerance.
MPLS	Multi-Protocol Label Switching (MPLS) is a networking protocol that labels the packet to direct traffic through a network.
MPLS header	MPLS header is a 32-bit header containing 20-bit MPLS label value and other related information.
SR	Segment routing is a technique where the sender of a packet can partially or entirely specify a route in a network through which a packet is sent. It is a form of source routing where nodes and links are represented as segments.
SR entropy	Segment Routing Entropy is a mechanism in SR that enables load-balancing across multiple paths.
TILFA	Topology Independent Loop Free Alternate (TILFA) paths are redundant backup paths that transfer the data packet without looping back to the source.

CHAPTER 21 Bridge Virtual Interface (BVI) Over L3VPN

Overview

A Bridge Virtual Interface (BVI) is a virtual interface on a router that acts like a routed interface and is associated with a single bridge domain.

BVI Interface acts as L3 routed interface gateway between bridge domain and L3VPN for traffic exchange. The incoming tagged packet from the L2 sub-interface consolidated itself into a bridge domain. The bridge domain in turn uses the BVI interface to forward the IP traffic to the L3VPN tunnel.

Characteristics of BVI Over L3VPN

- The BVI functions as an L3 routed interface for a bridge domain, allowing IP traffic from L2 subinterfaces within the domain to be routed to L3VPN tunnels.
- L2 subinterfaces can be grouped into a bridge domain under the BVI. The BVI aggregates traffic from multiple subinterfaces within the same domain and routes it as required.
- The BVI remains operationally “up” as long as at least one of the subinterfaces in the bridge domain is active.
- BVI supports unicast forwarding of IPv4 traffic between other L3 interfaces and L3VPNs. The BVI can function as a DHCP server or relay for IP address allocation within the network.

Benefits

- The BVI enables seamless communication between L2 bridge domains and L3 networks (e.g., L3VPN), allowing for flexible traffic forwarding between the two layers.
- The BVI serves as an L3 gateway for M-plane traffic, routing it efficiently to L3VPN tunnels for further processing or external routing.
- The BVI remains operational even if only one subinterface is active, ensuring high availability and fault tolerance.

Limitations

- Only Q2-based platforms are supported.
- Everything related to ipv6 is not supported
- L2 sub interfaces support only pop and pop2-tag vlan rewrite translations and for the purpose of bridge-domain support, all member L2 sub interfaces should have relevant rewrite configurations to make sure that all traffic for bridge-domain has uniform encapsulation.
- The dot1q and dot1ad encapsulations with range are not supported for the BVI.
- BVI is a generic L3 interface and allows users to configure any / all existing OcNOS features. However, only a few of these are supported in release 6.6.0 and those are IP address related, VRF, any routing protocol specific commands (OSPF/IS-IS/BGP related), MTU, DHCP server/relay, Ingress/Egress ACL and QoS commands related to marking.
- L3 ACL applied at BVI is only relevant for routed traffic. Bridged traffic between L2 sub-interfaces will not be subjected to L3 ACL configured at BVI.
- No Interface counters are supported for BVI Interface.
- BVI can’t be used as a network interface for all transports in MPLS core network.

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- For QoS, only marking related CLIs are supported. Policing, rate limiting, shaping and other queuing features are not supported at BVI level. However, existing QoS scheduling and queuing features on other interfaces can be used in conjunction with the BVI interface.
- VRRP over the BVI interface is not supported.
- TWAMP support along with QoS shaping and Queuing for BVI is planned for future releases.
- BUM traffic is not supported.

Prerequisites

- Define Interfaces and Loopback Addresses:
  Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish efficient network routing and communication.

```
interface lo
 ip address 127.0.0.1/8
 ip address 135.1.1.27/32 secondary
 ipv6 address ::1/128

interface po6
ip address 10.1.1.1/30
interface xe6
channel-group 6 mode active
```

- Configure IGP for Dynamic Routing:
  Enable ISIS to facilitate dynamic routing on all nodes within the network. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution.Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.
  - ISIS Configuration:

```
router isis 1
 is-type level-2-only
 metric-style wide
 mpls traffic-eng router-id 10.12.183.1
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 fast-reroute ti-lfa level-2 proto ipv4
 net 49.0000.0000.0027.00
 passive-interface lo

interface po6
 isis network point-to-point
 ip router isis 1
```

  - OSPF Configuration:

```
router ospf 100
ospf router-id 10.12.183.1
network 10.12.183.1/32 area 0.0.0.0
network 10.1.1.0/24 area 0.0.0.0
network 10.1.1.0/24 area 0.0.0.0
```

- Configure LDP for Label Transport:
  Configure label-switching on all the nodes to help exchange the network packets at a lower lever rather than the traditional network layer and enable ldp to transport those labels.

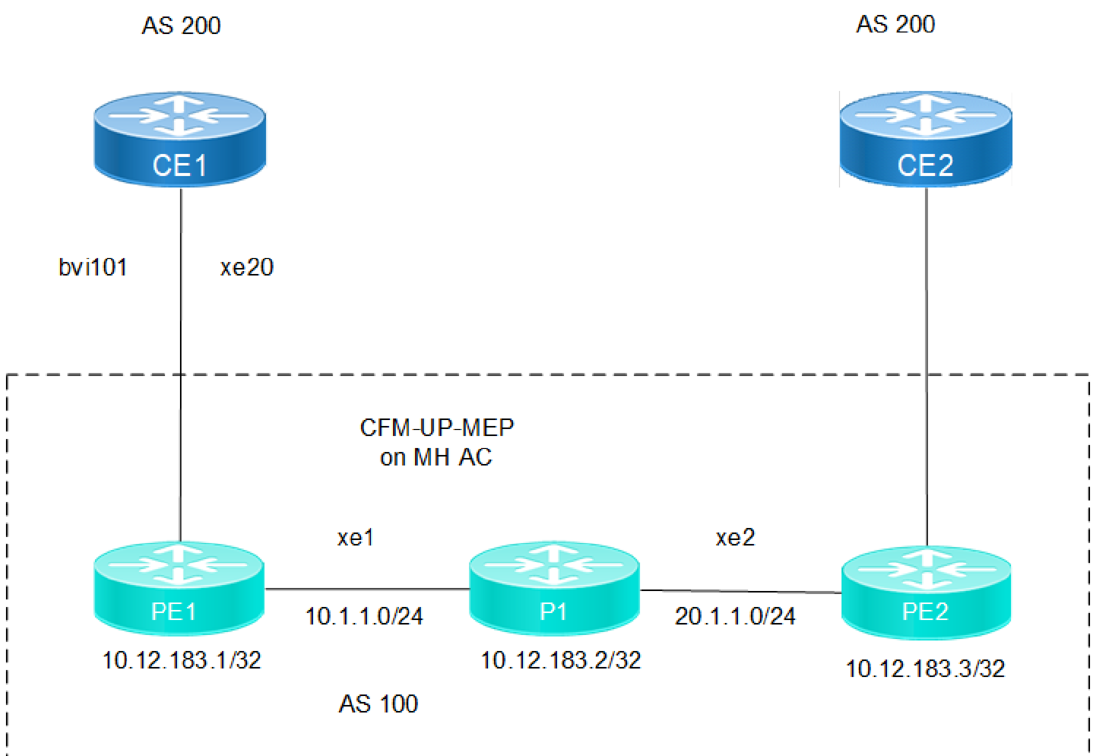
```
router ldp
targeted-peer ipv4 10.12.183.3
exit-targeted-peer
transport address ipb4 10.12.183.1

Interface po6
label-switching
enable-ldp ipv4
```

Configuration

Topology

The sample topology includes Edge nodes (PE1 and PE2), core Node (P1), and Customer Edge nodes (CE1 and CE2).



BVI Interface Topology

CE1

1. Set up the interface with VLAN encapsulation and assign an IP address.

```
CE1(config)#interface xe20.101
CE1(config-if)#encapsulation dot1q 101
CE1(config-if)#ip address 101.0.1.2/24
CE1(config-if)#exit
```

2. Configure BGP with a neighbor in the same AS (200).

```
CE1(config)# router bgp 200
CE1(config-router)# neighbor 101.0.1.1 remote-as 100
CE1(config-router)#address-family ipv4 unicast
CE1(config-router-af)#neighbor 101.0.1.1 activate
CE1(config-router-af)#exit-address-family
CE1(config-router)#exit
```

PE1

1. Create a VRF instance (VRF101) and define route targets.

```
PE1(config)# ip vrf VRF101
PE1(config-vrf)# rd 10.12.183.1:100
PE1(config-vrf)# route-target both 100:101
PE1(config-vrf)# exit
```

2. Configure the access port with VLAN encapsulation and enable rewriting.

```
PE1(config)#interface xe20.101 switchport
PE1(config-if)#encapsulation dot1q 101
PE1(config-if)#rewrite pop
PE1(config-if)# exit
```

3. Set up a BVI (Bridge Virtual Interface) for VRF forwarding.

```
PE1(config)# interface bvi101
PE1(config-if)#ip vrf forwarding VRF101
PE1(config-if)#ip address 101.0.1.1/24
PE1(config-f)# exit
```

4. Configure BGP with internal (PE) and external (CE) neighbors.

```
PE1(config)# router bgp 100
PE1(config-router)# neighbor 10.12.183.3 remote-as 100
PE1(config-router)# neighbor 10.12.183.3 update-source lo
PE1(config-router)#address-family ipv4 unicast
PE1(config-router-af)#neighbor 10.12.183.3 activate
PE1(config-router-af)#exit-address-family
PE1(config-router)#address-family vpnv4 unicast
PE1(config-router-af)#neighbor 10.12.183.3 activate
PE1(config-router-af)#exit-address-family
```

5. Enable VPNv4 and redistribute connected routes.

```
PE1(config-router)#address-family ipv4 vrf VRF101
PE1(config-router-af)#redistribute connected
PE1(config-router-af)#neighbor 101.0.1.2 remote-as 200
PE1(config-router-af)# neighbor 101.0.1.2 activate
PE1(config-router-af)#exit-address-family
PE1(config-router)#exit
```

6. Set up a bridge domain to associate the interface with BVI.

```
PE1(config)# bridge-domain 101
PE1(config)#interface xe20.101
PE1(config)#routed-interface bvi101
```

PE2

1. Create the same VRF instance (VRF101) with route targets.

```
PE2(config)# ip vrf VRF101
PE2(config-vrf)# rd 10.12.183.3:100
PE2(config-vrf)# route-target both 100:101
PE2(config-vrf)#exit
```

2. Configure the access port with VLAN encapsulation and VRF forwarding.

```
PE2(config)# interface xe30.101
PE2(config-if)#encapsulation dot1q 101
PE2(config-if)#ip vrf forwarding VRF101
```

```
PE2(config-if)#ip address 103.0.1.1/24
PE2(config-f)# exit
```

3. Assign an IP address to the interface.

```
PE2(config)# router bgp 100
PE2(config-router)# neighbor 10.12.183.1 remote-as 100
PE2(config-router)# neighbor 10.12.183.1 update-source lo
PE2(config-router)#address-family ipv4 unicast
PE2(config-router-af)#neighbor 10.12.183.1 activate
PE2(config-router-af)#exit-address-family
```

4. Configure BGP with internal (PE) and external (CE) neighbors.

```
PE2(config-router)#address-family vpnv4 unicast
PE2(config-router-af)#neighbor 10.12.183.1 activate
PE2(config-router-af)#exit-address-family
```

5. Enable VPNv4 and redistribute connected routes.

```
PE2(config-router)#address-family ipv4 vrf VRF101
PE2(config-router-af)#redistribute connected
PE2(config-router-af)#neighbor 103.0.1.2 remote-as 200
PE2(config-router-af)# neighbor 103.0.1.2 activate
PE2(config-router-af)#exit-address-family
PE2(config-router)#exit
```

CE2

1. Set up the interface with VLAN encapsulation and assign an IP address.

```
CE2#configure terminal
CE2(config)#interface xe30.101
CE2(config-if)#encapsulation dot1q 101
CE2(config-if)#ip address 103.0.1.2/24
CE2(config-if)#exit
```

2. Configure BGP with a neighbor in the same AS (200).

```
CE2(config)# router bgp 200
CE2(config-router)# neighbor 101.0.1.1 remote-as 100
CE2(config-router)#address-family ipv4 unicast
CE2(config-router-af)#neighbor 101.0.1.1 activate
CE2(config-router-af)#exit-address-family
CE2(config-router)#exit
```

Running configuration on CE1 router is as follows:

```
#show running-config
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
!
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
```

```
hardware-profile statistics ingress-acl enable
!
qos enable
!
hostname CE1
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
lldp run
lldp tlv-select basic-mgmt port-description
lldp tlv-select basic-mgmt system-name
lldp tlv-select basic-mgmt system-capabilities
lldp tlv-select basic-mgmt system-description
lldp tlv-select basic-mgmt management-address
lldp notification-interval 1000
!
ip vrf management
!
interface ce0
!
interface ce1
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128

interface xe20
!
interface xe20.101
 encapsulation dot1q 101
 ip address 101.0.1.2/24
!
router bgp 200
 neighbor 101.0.1.1 remote-as 100
 !
 address-family ipv4 unicast
 neighbor 101.0.1.1 activate
 exit-address-family
```

```
  !
  exit
 !
 !
 end
```

Running configuration on PE1 router is as follows:

```
#show running-config
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
!
service password-encryption
!
logging console 5
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile filter ingress-ipv4-ext enable
hardware-profile filter egress-ipv4-ext enable
hardware-profile statistics voq-full-color enable
hardware-profile statistics cfm-ccm enable
!
qos enable
!
hostname PE1
port ce2 breakout 4X10g
no ip domain-lookup
ip domain-lookup vrf management
ip name-server vrf management 10.12.3.23
bridge 1 protocol ieee vlan-bridge
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
snmp-server enable snmp vrf management
snmp-server view all .1 included vrf management
snmp-server community test vrf management
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
feature rsyslog
logging remote server 10.12.100.252 5 port 1514 vrf management
lldp run
lldp tlv-select basic-mgmt port-description
lldp tlv-select basic-mgmt system-name
lldp tlv-select basic-mgmt system-capabilities
lldp tlv-select basic-mgmt system-description
lldp tlv-select basic-mgmt management-address
```

```
lldp notification-interval 1000
fault-management enable
!
router-id 10.12.183.1
!
ip vrf management
!
ip vrf VRF101
 rd 10.12.183.1:100
 route-target both 100:101
!
router ldp
 fast-reroute
 session-protection duration 40
 targeted-peer ipv4 10.12.183.3
  exit-targeted-peer-mode
 transport-address ipv4 10.12.183.1
!
router rsvp
!
interface po6
 ip address 10.1.1.1/24
 label-switching
 ip router isis ISIS-IGP-100
 enable-ldp ipv4
!
interface bvi101
 ip vrf forwarding VRF101
 ip address 101.0.1.1/24
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 10.12.183.1/32 secondary
 ipv6 address ::1/128
 ip router isis ISIS-IGP-100
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe1
 channel-group 6 mode active
!
interface xe20
!
interface xe20.101 switchport
 encapsulation dot1q 101
 rewrite pop
!

 exit
!
```

```
router ospf 100
 ospf router-id 10.12.183.1
 network 10.1.1.0/24 area 0.0.0.0
 network 10.12.183.1/32 area 0.0.0.0
!
router isis ISIS-IGP-100
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id 10.12.183.1
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0001.00
 passive-interface lo
!
router bgp 100
 neighbor 10.12.183.3 remote-as 100
 neighbor 10.12.183.3 update-source lo
 !
 address-family ipv4 unicast
 neighbor 10.12.183.3 activate
 exit-address-family
 !
 address-family vpnv4 unicast
 neighbor 10.12.183.3 activate
 exit-address-family
 !
 address-family ipv4 vrf VRF101
 redistribute connected
 neighbor 101.0.1.2 remote-as 200
 neighbor 101.0.1.2 activate
 exit-address-family
 !
 exit
!
bridge-domain 100
 interface xe20.101
 routed-interface bvi101
!
!
end
```

Running configuration on P1 router is as follows:

```
#show running-config
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
!
service password-encryption
!
logging console 5
```

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```
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics voq-full-color enable
hardware-profile statistics cfm-ccm enable
!
qos enable
!
hostname P1
no ip domain-lookup
ip domain-lookup vrf management
ip name-server vrf management 10.12.3.23
bridge 1 protocol ieee vlan-bridge
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
snmp-server enable snmp vrf management
snmp-server view all .1 included vrf management
snmp-server community test vrf management
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
lldp run
lldp tlv-select basic-mgmt port-description
lldp tlv-select basic-mgmt system-name
lldp tlv-select basic-mgmt system-capabilities
lldp tlv-select basic-mgmt system-description
lldp tlv-select basic-mgmt management-address
lldp notification-interval 1000
!
router-id 10.12.183.2
!
ip vrf management
!
router ldp
 transport-address ipv4 10.12.183.2
!
router rsvp
!
interface po6
 ip address 10.1.1.2/24
 label-switching
 ip router isis ISIS-IGP-100
 enable-ldp ipv4
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 10.12.183.2/32 secondary
```

```
 ipv6 address ::1/128
 ip router isis ISIS-IGP-100
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe1
 channel-group 6 mode active
!
interface xe2
 ip address 20.1.1.1/24
 label-switching
 ip router isis ISIS-IGP-100
 enable-ldp ipv4
!
 exit
!
router ospf 100
 ospf router-id 10.12.183.2
 network 10.1.1.0/24 area 0.0.0.0
 network 10.12.183.2/32 area 0.0.0.0
 network 20.1.1.0/24 area 0.0.0.0
!
router isis ISIS-IGP-100
  is-type level-1
 metric-style wide
 mpls traffic-eng router-id 10.12.183.2
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0002.00
 passive-interface lo
!
end
```

Running configuration on PE2 router is as follows:

```
#show running-config
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
!
service password-encryption
!
logging console 5
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
hardware-profile statistics ac-lif enable
```

```
!
qos enable
!
hostname PE2
no ip domain-lookup
ip domain-lookup vrf management
ip name-server vrf management 10.12.3.23
bridge 1 protocol ieee vlan-bridge
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
snmp-server enable snmp vrf management
snmp-server view all .1 included vrf management
snmp-server community test vrf management
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
lldp run
lldp tlv-select basic-mgmt port-description
lldp tlv-select basic-mgmt system-name
lldp tlv-select basic-mgmt system-capabilities
lldp tlv-select basic-mgmt system-description
lldp tlv-select basic-mgmt management-address
lldp notification-interval 10
!
router-id 10.12.183.3
!
ip vrf management
!
ip vrf VRF101
 rd 10.12.183.3:100
 route-target both 100:101
!
router ldp
 fast-reroute
 session-protection duration 40
 targeted-peer ipv4 10.12.183.1
  exit-targeted-peer-mode
 transport-address ipv4 10.12.183.3
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 10.12.183.3/32 secondary
 ipv6 address ::1/128
 ip router isis ISIS-IGP-100
!
interface lo.management
 ip vrf forwarding management
```

```
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe2
 ip address 20.1.1.2/24
 label-switching
 ip router isis ISIS-IGP-100
 enable-ldp ipv4
!
interface xe30
!
interface xe30.101
 description L3VPN-VRF101
 encapsulation dot1q 101
 ip vrf forwarding VRF101
 ip address 103.0.1.1/24
!
 exit
!
router ospf 100
 ospf router-id 10.12.183.3
 network 10.12.183.3/32 area 0.0.0.0
 network 20.1.1.0/24 area 0.0.0.0
!
router isis ISIS-IGP-100
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id 10.12.183.3
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp
 bfd all-interfaces
 net 49.0001.0000.0000.0003.00
 passive-interface lo
!
router bgp 100
 neighbor 10.12.183.1 remote-as 100
 neighbor 10.12.183.1 update-source lo
 !
 address-family ipv4 unicast
 neighbor 10.12.183.1 activate
 exit-address-family
 !
 address-family vpnv4 unicast
 neighbor 10.12.183.1 activate
 exit-address-family
 !
 address-family ipv4 vrf VRF101
 redistribute connected
 neighbor 103.0.1.2 remote-as 200
 neighbor 103.0.1.2 activate
 exit-address-family
 !
 exit
!
end
```

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Running configuration on CE2 router is as follows:

```
#show running-config
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
!
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!
hostname CE2
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
lldp run
lldp tlv-select basic-mgmt port-description
lldp tlv-select basic-mgmt system-name
lldp tlv-select basic-mgmt system-capabilities
lldp tlv-select basic-mgmt system-description
lldp tlv-select basic-mgmt management-address
lldp notification-interval 1000
!
ip vrf management
!

interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
```

```
interface xe30
!
interface xe30.101
 encapsulation dot1q 101
 ip address 103.0.1.2/24
!
router bgp 200
 neighbor 103.0.1.1 remote-as 100
 !
 address-family ipv4 unicast
 neighbor 103.0.1.1 activate
 exit-address-family
 !
 exit
!
!
end
```

Validation

PE1

To Verify the L2 interfaces and BVI interface attached on a bridge domain:

```
PE1#show running-config bridge-domain
bridge-domain 101
Interface xe20.101
routed-interface bvi101
```

To Verify the link status of L2 Interfaces attached to bridge-domain:

```
PE1#show bridge-domain

Total number of bridge-domains Configured: 1

Bridge Id  interfaces       Status
----------+----------------+-----------
 101         xe20.101         UP
```

To Verify the link status of the BVI interface:

```
PE1#show ip interface bvi101 brief

'*' - address is assigned by dhcp client

Interface             IP-Address      Admin-Status          Link-Status
bvi101                101.0.1.1             up                   up
```

To Verify BGP session between PE1-CE1

```
PE1#show ip bgp summary
BGP router identifier 10.12.183.1, local AS number 100
BGP table version is 11
```

```
1 BGP AS-PATH entries
0 BGP community entries

Neighbor    V AS  MsgRcv MsgSen TblVer InQ OutQ Up/Down  State/PfxRcd   Desc
10.12.183.3 4 100 280     283     11    0   0  00:18:47        0

Total number of neighbors 1

Total number of Established sessions 1
BGP router identifier 101.0.1.1, local AS number 100
BGP VRF VRF101 Route Distinguisher: 10.12.183.1:100
BGP table version is 1
1 BGP AS-PATH entries
0 BGP community entries

Neighbor   V  AS  MsgRcv  MsgSen TblVer InQ OutQ Up/Down  State/PfxRcd   Desc
101.0.1.2  4  200   10      13     1     0    0  00:03:54        0

Total number of neighbors 1

Total number of Established sessions 1
```

To Verify the route between PE1-CE1

```
PE1#show ip route vrf VRF101
IP Route Table for VRF "VRF101"
C           101.0.1.0/24 is directly connected, bvi101, installed 01:59:42, last update
01:59:42 ago
C            127.0.0.0/8 is directly connected, lo.VRF101, installed 01:59:46, last
update 01:59:46 ago
```

To Verify vrf Ping between PE1-CE1

```
PE1#ping ip vrf VRF 101.0.1.2 vrf VRF101
Press CTRL+C to exit
PING 101.0.200.2 (101.0.200.2) 100(128) bytes of data.
108 bytes from 101.0.200.2: icmp_seq=1 ttl=64 time=0.432 ms
108 bytes from 101.0.200.2: icmp_seq=2 ttl=64 time=0.427 ms
108 bytes from 101.0.200.2: icmp_seq=3 ttl=64 time=0.348 ms

--- 101.0.200.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2070ms
rtt min/avg/max/mdev = 0.348/0.402/0.432/0.038 ms
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
BUM	Broadcast, Unknown, Multicast
BVI	Bridge Virtual Interface
L3VPN	Layer 3 Virtual Private Network
IGP	Interior Gateway Protocol
ISIS	Intermediate System to Intermediate System
OSPF	Open Shortest Path First
LDP	Label Distribution Protocol

CHAPTER 22 EVPN EPL Link-Loss Forwarding

Overview

Link Loss Forwarding (LLF) is a fault propagation feature for EVPN Ethernet Private Line (EPL) services that ensures reliable point-to-point connections on physical interfaces. It prevents traffic blackholing by detecting remote service failures and bringing the local physical link operationally down, enabling the local end to trigger a traffic failover mechanism. LLF is supported on all Broadcom chipsets and uses Ethernet Auto-Discovery (AD) per EVI (RT-1) route withdrawal for fault propagation, which is enabled by default.

The feature can be configured per service using the CLI command llf enable in interface mode. By facilitating proactive fault handling, LLF ensures minimal downtime, improves service reliability, and enhances traffic management for customers relying on point-to-point connections.

Feature Characteristics

Link Loss Forwarding (LLF) enhances the reliability of EVPN Ethernet Private Line (EPL) connections by detecting remote failures, bringing the local link down to initiate failover, and preventing traffic blackholing. It ensures prompt communication of service interruptions to minimize downtime and prevent data loss.

Benefits

LLF enhances networking environments by ensuring minimal service downtime, reliable traffic failover, and increased network stability.

- **Minimized Service Downtime**: Quick detection and propagation of faults reduce recovery time.
- **Traffic Failover Assurance**: Reliable failover mechanisms are enabled, ensuring minimal impact on customer services.
- **Improved Network Reliability**: The proactive nature of LLF enhances the robustness of EVPN EPL services.

Configuration of LLF for an EVPN Ethernet Private Line (EPL)

To configure LLF on an interface, follow the below steps to ensure that network faults are managed effectively, preventing traffic loss or blackholing by administratively adjusting the status of affected interfaces based on the fault condition.

Topology

The topology consists of two Customer Edge devices (CE1 and CE2) connected to Provider Edge devices (PE1 and PE2) through sub-interfaces. The Provider Edge devices are interconnected through MPLS. In this topology, the Link Loss Forwarding (LLF) configuration for an EVPN Ethernet Private Line (EPL) service ensures fault propagation to prevent traffic blackholing during link failures. When a link failure occurs, such as between CE-1 and PE-1 on interface xe1.1, PE-1 detects the issue and withdraws the Ethernet Auto-Discovery (AD) per EVI (RT-1) route. This withdrawal is propagated through the MPLS network to PE-2, which then takes action to bring down the corresponding physical interface (xe22.2). This mechanism ensures the fault is communicated end-to-end, allowing CE-2 to detect the failure and trigger failover mechanisms. LLF is enabled through the LLF enable command at the interface level, ensuring automated fault detection and seamless service continuity.

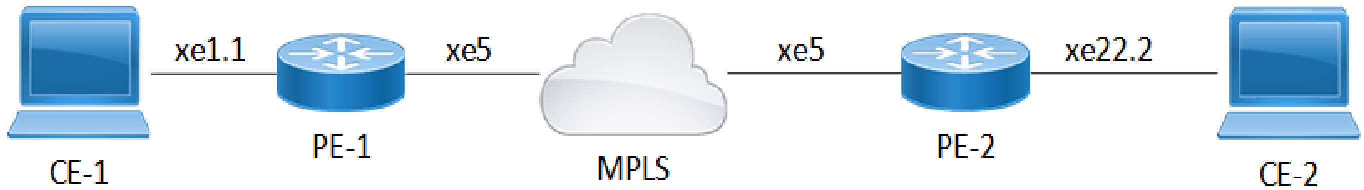

Figure 22-11: Link-loss Forwarding Topology

Configuration XE22.2

Follow these steps to configure LLF on PE2.

1. Access the interface configuration mode, configure the interface xe22.2. Set the interface as a switch port.
```
PE2(config)#configure terminal
PE2(config)#int xe22.2 sw
```
2. Specify the encapsulation type as dot1q and set the VLAN ID to 10. Enable the interface to support EVPN services.
```
PE2(config-if)#encapsulation dot1q 10
PE2(config-if)#access-if-evpn
```
3. Enable LLF on the interface to ensure link failure detection and recovery. Save the changes and exit the configuration mode.
```
PE2(config-acc-if-evpn)#llf-enable
PE2(config)#commit
PE2(config)#exit
```

Validation

To validate the proper configuration of Link Loss Forwarding (LLF), use the show running-config interface xe22.2 command to inspect the interface settings. Ensure that the interface is configured with switchport, encapsulation dot1q 10 for VLAN tagging, access-if-evpn to enable EVPN on the interface, llf-enable to activate LLF, and map vpn-id 10 to associate the service with the correct VPN ID. Verify that these attributes are present and correctly configured. If discrepancies are found, update the configuration and recheck to ensure the LLF setup is correct and operational.

```
#show running-config interface xe22.2
interface xe22.2 switchport
 encapsulation dot1q 10
 access-if-evpn
  llf-enable
  map vpn-id 10
!
Rvtep#sh evpn mpls llf-status
status : is_up\is_running
```

```
ifp-name            sub-Ifname          llf-configured  RT-1-rcvd   llf-
action
_______________________________________________________________________________
xe16 (DOWN\---)     xe16.2 (UP\---)     YES             NO          YES

Total number of entries are 1

Rvtep#sh int brief
xe16.2       SUBINTERFACE  --    --              down    PD     10g   --
No  No

Rvtep#sh int xe16
Interface xe16
  Flexport: Non Control Port (Active)
  Hardware is ETH  Current HW addr: e8c5.7a8f.c60e
  Physical:e8c5.7a8f.c60e  Logical:(not set)
  Forward Error Correction (FEC) configured is Auto (default)
  FEC status is N/A
  Port Mode is Router
  Protected Mode is Promiscuous
  Interface index: 10037
  GMPLS index: 39
  Metric 1 mtu 1500 duplex-full  link-speed 10g
  Debounce timer: disable
  ARP ageing timeout 1500
  <BROADCAST,MULTICAST>
  Reason: LLF DOWN
  VRF Binding: Not bound
  Label switching is disabled
  No Virtual Circuit configured
  Administrative Group(s): None
 Regular Extended-Admin-Group(s): None
 Anomaly Extended-Admin-Group(s): None
  Bandwidth 10g
  Maximum reservable bandwidth 10g
    Available b/w at priority 0 is 10g
    Available b/w at priority 1 is 10g
    Available b/w at priority 2 is 10g
    Available b/w at priority 3 is 10g
    Available b/w at priority 4 is 10g
    Available b/w at priority 5 is 10g
    Available b/w at priority 6 is 10g
    Available b/w at priority 7 is 10g
  DHCP client is disabled.
  Last Flapped: 2024 Oct 25 21:46:12 (00:00:44 ago)
  Load Interval: 30 seconds.
  Statistics last cleared: Never
  inet6 fe80::eac5:7aff:fe8f:c60e/64
  ND router advertisements are sent approximately every 442 seconds
  ND next router advertisement due in 0 seconds.
  ND router advertisements live for 1800 seconds
  Hosts use stateless autoconfig for addresses.
  RX
    unicast packets 0 multicast packets 0 broadcast packets 0
    input packets 0 bytes 0
    jumbo packets 0
    undersize 0 oversize 0 CRC 0 fragments 0 jabbers 0
```

```
      input error 0
      input with dribble 0 input discard 0
      Rx pause 0
    TX
      unicast packets 0 multicast packets 10 broadcast packets 0
      output packets 10 bytes 1020
      jumbo packets 0
      output errors 0 collision 0 deferred 0 late collision 0
      output discard 0
      Tx pause 0
Rvtep#
```

New CLI Commands

The llf introduces the following configuration commands in OcNOS.

llf-enable

Use this command to enable the link-loss forwarding on an access-interface.

Use the no parameter to disable the load interval globally.

Command Syntax

```
llf-enable
no llf-enable
```

Parameters

None

Default

Disabled

Command Mode

Access-if mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

The following example illustrates how to activate EVPN Ethernet Private Line (EPL).

```
#configure terminal
(config)#int xe22.2 sw
(config-if)#encapsulation dot1q 10
(config-if)#access-if-evpn
(config-acc-if-evpn)#llf-enable
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

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Key Terms/Acronym	Description
LLF	Link Loss Forwarding (LLF) is a feature in networking, particularly in Ethernet-based networks like Ethernet Virtual Private Network (EVPN), that is designed to prevent traffic blackholing during link failures.
EPL	Ethernet Private Line (EPL) is a high-performance, point-to-point Ethernet service used for dedicated connectivity between two locations.
MPLS	Multiprotocol Label Switching (MPLS) is a high-performance routing technique used in modern telecommunications networks to efficiently route data packets.

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Multi-Protocol Label Switching Command Reference

CHAPTER 1 **MPLS Commands**

This chapter is a reference for the MPLS commands:

- bandwidth
- control-word
- clear mpls counters ldp
- clear mpls counters rsvp
- clear mpls counters static
- clear mpls l2-circuit statistics
- flow-label
- group-id
- group-name
- label-switching
- manual-pseudowire
- match vlan
- mpls ac-group
- admin-groups
- mpls bandwidth-class
- mpls ftn-ecmp ldp
- mpls ftn-entry tunnel-id
- mpls ftn-entry
- mpls ilm-ecmp ldp
- mpls ilm-entry pop
- mpls ilm-entry swap
- mpls ingress-ttl
- mpls l2-circuit
- mpls-l2-circuit NAME
- mpls l2-circuit-fib-entry
- mpls label mode
- mpls local-packet-handling
- mpls lsp-encap-dscp-preserve
- mpls lsp-model uniform
- mpls lsp-stitching
- mpls map-route
- mpls min-label-value
- mpls propagate-ttl

- mpls traffic-eng srlg
- pce entity
- pce lsp-delegate
- pce state-report
- ping mpls
- secondary srlg-disjoint
- secondary-priority srlg-disjoint
- service-tpid
- rewrite ingress
- service-template
- show mpls
- show admin-groups
- show mpls bandwidth-class
- show mpls counters ldp
- show mpls counters rsvp
- show mpls counters static
- show mpls cross-connect-table
- show mpls cross-connect-table backup
- show mpls forwarding-table detail
- show mpls forwarding-table
- show mpls ftn-table
- show mpls ilm-table
- show mpls in-segment-table
- show mpls l2-circuit
- show mpls l2-circuit statistics
- show mpls mapped-routes
- show mpls out-segment-table
- show mpls qos-resource
- show mpls vc-table
- show mpls vrf
- show mpls vrf-forwarding-table vrf
- show running-config interface mpls
- show running-config mpls
- show running-config service-template
- show running-config vc
- show running-config vpls
- show service-template
- show vccv statistics
- srlg-disjoint

bandwidth

Use this command to specify the maximum bandwidth to be used for a band-class. The bandwidth value is in bits.

Note: Run this command in the Bandwidth-class mode (refer to mpls bandwidth-class).

Command Syntax

```
bandwidth BANDWIDTH setup-priority <0-7> hold-priority <0-7>
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilo bits/s
	<1-999>m for 1 to 999 mega bits/s
	<1-100>g for 1 to 100 giga bits/s
setup-priority	Indicate the setup-priority parameter
<0-7>	The actual setup priority value
hold-priority	Indicate the hold-priority parameter
<0-7>	The actual hold priority value

Default

By default, bandwidth priority is 0

Command Mode

Bandwidth-class mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls bandwidth-class new-BC
(config-mpls-bw)#bandwidth 100m setup-priority 1 hold-priority 1
```

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control-word

Use this command to enable control word for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable control word from the MPLS layer-2 virtual circuit.

Command Syntax:

```
control-word
no control-word
```

Parameters

NA

Default

By default, control-word is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#control-word
```

clear mpls counters ldp

Use this command to clear traffic statistics for FTNs and ILMs configured by LDP.

Command Syntax

```
clear mpls counters ldp ((ftn (|A.B.C.D/M)) | (ilm (|A.B.C.D/M)) |)
```

Parameter

`ftn`	FEC-to-NHLFE map counters
`A.B.C.D/M`	FEC prefix
`ilm`	Incoming label map counters
`A.B.C.D/M`	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear mpls counters ldp
```

clear mpls counters rsvp

Use this command to clear traffic statistics for LSPs configured by RSVP.

Command Syntax

```
clear mpls counters rsvp ((tunnel-name NAME) | (tunnel-id TUNNEL_ID) | (node-role
  (ingress | transit | egress)) |)
```

Parameter

`NAME`	RSVP tunnel name
`TUNNEL_ID`	RSVP tunnel identifier
`ingress`	LSP role is ingress
`transit`	LSP role is transit
`egress`	LSP role is egress

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear mpls counters rsvp
```

clear mpls counters static

Use this command to clear traffic statistics for statically configured FTNs and ILMs.

Command Syntax

```
clear mpls counters static ((ftn (|A.B.C.D/M)) | (ilm (|A.B.C.D/M)) |)
```

Parameter

`ftn`	FEC-to-NHLFE map counters
`A.B.C.D/M`	FEC prefix
`ilm`	Incoming label map counters
`A.B.C.D/M`	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear mpls counters static
```

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clear mpls l2-circuit statistics

Use this command to clear MPLS traffic statistics for l2 circuit.

Command Syntax

```
clear mpls l2-circuit NAME statistics(access-port|network-port|)
```

Parameters

`name`	Name of L2 circuit
`access-port`	Displays the access port statistics
`network-port`	Displays the network port statistics

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear mpls l2-circuit vcl statistics
```

flow-label

Use this command to to enable flow-label transmit, receive or both for the MPLS layer-2 virtual circuit and mpls vpls on dynamic and static VPWS and VPLS.

Use `no` command to disable flow-label transmit, receive or both for the MPLS layer-2 virtual circuit and mpls vpls on dynamic and static VPWS and VPLS.

For signaling flow-label capability in an RFC-compliant (RFC6391/8077) way using "The PWid FEC Element " = 0x80 when all Interface Parameter Sub-TLV is part of PWid FEC Element to support interop with other vendors, then interface-param-tlv can be used.

Command Syntax

```
flow-label (both|receive|transmit)(static|interface-param-tlv|)
no flow-label(static|interface-param-tlv|)
```

Parameters

`both`	flow label direction both (transmit and receive)
`receive`	flow label direction receive
`transmit`	flow label direction transmit
`static`	flow-label static
`interface-param-tlv`	ldp specific interface parameter tlv

Command Mode

config-pseudowire mode and config-vpls mode

Applicability

This command was introduced in OcNOS version 6.0.0 and added parameter `interface-param-tlv` in OcNOS version 6.3.0 to support interop with other vendors.

Example

For the config-pseudowire mode:

```
# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#flow-label transmit

# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#no flow-label
```

For the config-vpls mode:

```
# configure terminal
(config)#mpls vpls test 100
(config-vpls)# flow-label both

# configure terminal
(config)#mpls vpls test 100
(config-vpls)# no flow-label
```

For the static configuration:

```
# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#flow-label transmit static
```

For the config-vpls mode:

```
# configure terminal
(config)#mpls vpls test 100
(config-vpls)# flow-label both static

# configure terminal
(config)#mpls vpls test 100
(config-vpls)# no flow-label static
```

For the un-configuration of the static flow label:

For the config-pseudowire mode:

```
# configure terminal
(config)#mpls l2-circuit vc1111 1111 7.7.7.7
(config-pseudowire)#no flow-label static
```

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group-id

Use this command to configure a specific group identifier to existing group with a group name in the MPLS layer-2 virtual circuit.

Use the no parameter with this command to remove group identifier from the MPLS layer-2 virtual circuit

Command Syntax

```
group-id <1-4294967295>
no group-id
```

Parameters

`<1-4294967295>` Value for group identifier

Default

By default, group-id is disabled. If group-name is configured, default group-id is the first available identifier.

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#group-name group-1
(config-pseudowire)#group-id 11
```

group-name

Use this command to map the MPLS layer-2 virtual circuit with a specific group.

Use the no parameter with this command to remove group from the MPLS layer-2 virtual circuit

Command Syntax

```
group-name NAME
no group-name
```

Parameters

NAME	String identifying group NAME

Default

By default, group-name is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 6.0.0.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#group-name group-1
```

label-switching

Use this command to either enable label-switching on an interface or to modify the label-space to which this interface is bound.

Use the `no` parameter and the interface is bound to the platform-wide (zero) label-space.

Note: When label-switching enabled on VLAN interface, MTU value must be manually increased by at least 20 bytes on Parent interfaces of VLAN. Example, default MTU must be set as 1520 instead of 1500 on label-switching parent interface label switched VLAN interface. (Parent Interface MTU >= label switched VLAN interface MTU + 20).

Command Syntax

```
label-switching
label-switching <0-60000>
no label-switching
```

Parameter

`<0-60000>`	Label space value in this range

Default

By default, label switching is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows the enabling of label switching on the `eth0` interface.

```
#configure terminal
(config)#interface eth0
(config-if)#label-switching 654
```

manual-pseudowire

Use this command to configure the MPLS layer-2 virtual circuit as manual. This disables the default signalling mode of the MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable manual mode of the MPLS layer-2 virtual circuit & enable signalling mode of the MPLS layer-2 virtual circuit.

Command Syntax

```
manual-pseudowire
no manual-pseudowire
```

Parameters

NA

Default

By default, manual-pseudowire is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#manual-pseudowire
```

match vlan

Use this command to configure a match VLAN action for a service template.

Use the `no` parameter to remove a match VLAN action for a service template.

Command Syntax

```
match (all | double-tag outer-vlan <2-4094> inner-vlan VLAN_RANGE | outer-vlan
  VLAN_RANGE | untagged)
```

```
no match (double-tag outer-vlan <2-4094> inner-vlan VLAN_RANGE | outer-vlan
  VLAN_RANGE | untagged)
```

Parameter

`all`	Accept all matches
`double-tag`	Double tag match
`outer-vlan`	Double tag outer VLAN
`<2-4094>`	Outer VLAN identifier
`inner-vlan`	Double tag inner VLAN
`VLAN_RANGE`	VLAN identifier <2-4094> range: 2-5,10 or 2-5,7-19
`outer-vlan`	Single tag outer-VLAN
`VLAN_RANGE`	VLAN identifier <2-4094> range: 2-5,10 or 2-5,7-19
`untagged`	Match untagged. This parameter depends on the `switchport dot1q ethertype` configuration. Packets received with a TPID other than 0x8100 (default value) and the TPID value configured by `switchport dot1q ethertype` are treated as untagged. For example, if you give the command: `switchport dot1q ethertype 0x8888` then packets received with TPID 0x8100 or 0x88a8 are treated as tagged. Packets received with other TPIDs are treated as untagged.

Command Mode

MPLS SVC mode

Applicability

This command was introduced before OcNOS version 1.3 and updated in OcNOS version 3.0.

The inner vlan range option added in OcNOS version 4.1.

Example

```
#configure terminal
(config)#service-template C2
(config-svc)#match double-tag outer-vlan 10 inner-vlan 20
(config-svc)#exit
(config)#service-template C2
(config-svc)#no match double-tag outer-vlan 10 inner-vlan 20
(config-svc)#exit
#configure terminal
```

```
(config)#service-template C3
(config-svc)#match double-tag outer-vlan 10 inner-vlan 200-300
(config-svc)#exit
(config)#service-template C4
(config-svc)#no match double-tag outer-vlan 10 inner-vlan 200-300
(config-svc)#exit
#configure terminal
(config)#service-template t1
(config-svc)#match untagged
(config-svc)#rewrite ingress push 100
```

mpls ac-group

Use this command to create a new access circuit group for MPLS.

Use the `no` parameter with this command to remove an access circuit group.

Command Syntax

```
mpls ac-group NAME <1-4294967295>
no mpls ac-group NAME
```

Parameter

`NAME`	The name of the access circuit group
`<1-4294967295>`	The identifier for the group; used in LDP

Default

By default, mpls ac group is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls ac-group new-ac 123

(config)#no mpls ac-group new-ac
```

admin-groups

Use this command to create a name-to-value binding for an administrative group.

Note: Only 32 administrative groups can be configured at one time.

Use the `no` parameter with this command to remove a named administrative group.

Command Syntax

```
admin-group NAME <0-31>
no admin-group NAME <0-31>
```

Parameters

`NAME`	Name of administrative group
`<0-31>`	The value of the administrative group

Default

By default, mpls admin group is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#admin-group mygroup 3
```

mpls bandwidth-class

Use this command to create a new bandwidth class name. Using this command changes the command mode to Bandwidth-class mode.

Use the `no` parameter with this command to remove a bandwidth class name.

Command Syntax

```
mpls bandwidth-class NAME
no mpls bandwidth-class NAME
```

Parameter

NAME	Name of the bandwidth class

Default

By default, mpls bandwidth-class is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls bandwidth-class new-BC
(config-mpls-bw)#

(config)#no mpls bandwidth-class new-BC
```

mpls ftn-ecmp ldp

Use this command to enable Equal-Cost Multi-Path ECMP for Label Distribution Protocol (LDP) Forwarding Table Entry (FTN). FTN contains the details of forwarding the labeled packets.

Use `no` command to disable ECMP for LDP FTN.

Command Syntax

```
mpls ftn-ecmp ldp
no mpls ftn-ecmp ldp
```

Parameter

None

Default

Disabled

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 6.4.1.

Examples

The below example shows how to enable and disable ECMP for LDP FTN:

```
#configure terminal
(config)#mpls ftn-ecmp ldp
(config)# commit
(config)# no mpls ftn-ecmp ldp
(config)# commit
```

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mpls ftn-entry tunnel-id

This command will be used to create a static tunnel.

In hardware, it creates a logical interface to which services can be mapped.

Note: Only global label space is supported and per interface label space is not supported. MPLS core with IPv6 is not supported.

Command Syntax

```
mpls ftn-entry tunnel-id <1-5000> (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575> A.B.C.D
  IFNAME ((secondary|primary)|)

no mpls ftn-entry tunnel-id <1-5000> (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575>
  A.B.C.D IFNAME ((secondary|primary)|)

mpls ftn-entry tunnel-id <1-5000> X:X::X:X/M <16-1048575> X:X::X:X IFNAME
  ((secondary|primary)|)

no mpls ftn-entry tunnel-id <1-5000> X:X::X:X/M <16-1048575> X:X::X:X IFNAME
  ((secondary|primary)|)
```

Parameters

`<1-5000>`	The tunnel ID value
`A.B.C.D/M`	Forwarding equivalence class with mask
`A.B.C.D`	Mask for forwarding equivalency class
`<16-1048575>`	Outgoing label
`A.B.C.D`	Nexthop IPv4 address
`IFNAME`	Outgoing interface name
`primary`	The primary LSP; default is primary
`secondary`	The secondary LSP Command Mode
`X:X::X:X/M`	IPv6 Forwarding Equivalence Class with Mask
`X:X::X:X`	Nexthop IPv6 address

Default

By default, mpls ftn-entry tunnel-id are disabled

Command mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls ftn-entry tunnel-id 2 10.10.0.0/24 16 1.2.3.4 eth1 secondary
(config)#no mpls ftn-entry tunnel-id 2 10.10.0.0/24 16 1.2.3.4 eth1 secondary
```

mpls ftn-entry

Use this command to create a static LSP. In the hardware, this command creates an IP route with outgoing MPLS parameters.

Note: Only global label space is supported and per interface label space is not supported.

Command Syntax

```
mpls ftn-entry  (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575> A.B.C.D IFNAME
no mpls ftn-entry  (A.B.C.D/M|A.B.C.D A.B.C.D) <16-1048575> A.B.C.D IFNAME
```

Parameters

A.D.C.D/M	Forwarding Equivalence Class with Mask
A.B.C.D	Mask for forwarding equivalency class
<16-1048575>	Outgoing label <16-1048575>
A.B.C.D	Nexthop IPv4 address
IFNAME	Outgoing interface name

Default

By default, mpls ftn-entry are disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)# mpls ftn-entry 2.2.2.2/32 111 20.0.0.2 eth1
(config)# no mpls ftn-entry 2.2.2.2/32 111 20.0.0.2 eth1
```

mpls ilm-ecmp ldp

Use this to enable ECMP for LDP Incoming Label Map (ILM).

Use `no` of this to disable ECMP for LDP ILM.

Note: Entropy is also required to be configured for load-balancing to work.

Note: LDP has to be configured with no-php for entropy to work (Q1 platforms).

Command Syntax

```
mpls ilm-ecmp ldp
no mpls ilm-ecmp ldp
```

Parameters

None

Default

LDP ECMP on transit nodes is disabled. If LDP load-balancing is required on transit nodes, enable this option.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#mpls ilm-ecmp ldp
(config)#no mpls ilm-ecmp ldp
```

mpls ilm-entry pop

Use this command to create an ILM entry in the ILM table to which a POP incoming interface is bound. Upon receipt of a labeled packet on an MPLS-enabled router, a lookup is done based on the incoming label in the ILM table. If a match is found, the packet may either be label-switched downstream, or popped and passed over IP. In a pop operation, an outgoing label is not needed as is either accepted or forwarded over IP. The nexthop option is also not mandatory because the FEC IP address could be a local IP address.

Use the `no` option with the command to delete an ILM entry. If there is no match, an error message displays.

Note: Only global label space is supported and per interface label space is not supported.

Command Syntax

```
mpls ilm-entry <16-1048575> pop
no mpls ilm-entry <16-1048575> pop
```

Parameters

`<16-1048575>`	Incoming label value
`pop`	Pop the incoming label

Default

By default, mpls ilm-entry are disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls ilm-entry 100 pop
```

mpls ilm-entry swap

Use this command to create an ILM entry in the ILM table to which a swap incoming interface is bound. Upon receipt of a labeled packet on an MPLS-enabled router, a lookup is done based on the incoming label in the ILM table. If a match is found, the packet may either be label-switched downstream, or popped and passed over IP.

Use the `no` option with the command to delete an ILM entry. If there is no match, an error message displays.

Note: Only global label space is supported and per interface label space is not supported. MPLS core with IPv6 is not supported.

Command Syntax

```
mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME A.B.C.D (A.B.C.D/M|A.B.C.D
  A.B.C.D)
no mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME A.B.C.D (A.B.C.D/M|A.B.C.D
  A.B.C.D)
mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME X:X::X:X X:X::X:X/M
no mpls ilm-entry <16-1048575> swap <16-1048575> IFNAME X:X::X:X X:X::X:X/M
```

Parameters

`<16-1048575>`	Incoming label value range <16-1048575>
`swap`	Specify swap for the incoming label
`<16-1048575>`	Configure an outgoing label with a value from <16-1048575>

Note: A value of 2 indicates explicit NULL and a value of 3 indicates implicit NULL.

`IFNAME`	Outgoing interface name
`A.B.C.D`	Nexthop IPv4 address
`A.B.C.D`	The FEC for which this ILM entry is created
`A.B.C.D/M`	The FEC for which this ILM entry is created, plus mask
`A.B.C.D`	A mask for forwarding equivalence class mask
`X:X::X:X/M`	IPv6 FEC for which this ILM entry is being created, plus mask
`X:X::X:X`	Nexthop IPv6 address

Default

By default, mpls ilm-entry are disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3 and the incoming interface name parameter `IFNAME` is removed in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#mpls ilm-entry 16 swap 17 eth2 1.1.1.1 1.1.1.1/3
```

mpls ingress-ttl

Use this command to set a Time to Live (TTL) value for LSPs for which this LSR is the ingress.

Use the `no` parameter with this command to unset the custom TTL value being used for LSPs for which this LSR is the ingress.

Command Syntax

```
mpls ingress-ttl <0-255>
no mpls ingress-ttl
```

Parameter

`<0-255>`	Set the TTL value to use

Default

By default, mpls ingress-ttl value is 64

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls ingress-ttl 3
```

mpls l2-circuit

Use this command to create an instance of an MPLS layer 2 virtual circuit, without specifying a group to which the VC belongs. Refer to group-name for information on how to create an MPLS “with” a specific group. A Layer-2 MPLS Virtual Circuit instance may be bound to any interface on the router; however, only one interface may be bound to a Layer-2 circuit at a time.

Use the `no` parameter with this command to delete an instance of an MPLS Layer-2 Virtual Circuit.

Note: OcNOS supports configuring the same Virtual Circuit Identifier (VC-ID) with different VPWS names for different LDP neighbors.

Command Syntax

```
mpls l2-circuit NAME <1-4294967295> A.B.C.D
mpls l2-circuit NAME <1-4294967295> A.B.C.D mode raw
mpls l2-circuit NAME <1-4294967295> A.B.C.D mode tagged
no mpls l2-circuit NAME <1-4294967295> A.B.C.D
```

Parameters

`NAME`	String identifying the MPLS Layer-2 virtual circuit
`<1-4294967295>`	A 32-bit identifier to which the L2 circuit name should be mapped
`A.B.C.D`	IPv4 address for the MPLS L2 virtual circuit end-point

Default

By default, mpls l2-circuit is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
```

mpls-l2-circuit NAME

Use this command in the Interface mode to bind an interface to a MPLS Layer-2 Virtual Circuit created in the configure mode. The qos profiles cos-to-queue and queue-color-to-cos are optional parameters and are configurable dynamically on the virtual circuit by repeating mpls-l2-circuit command along with one or both profile options. In order to dynamically unbind the profile, same command pattern should be repeated by removing the profile which needs to be unbound from the command. Refer 'qos profile' commands from configuration guide for more details about qos profiles.

Use the `no` parameter with this command to delete this instance.

Note: QoS profiles are supported only on vlan based virtual circuits. For port based virtual circuits (service template with match-all option), qos profiles can be bound to interface which will take effect, otherwise default qos profile will take effect. Refer 'qos map-profile' command for binding qos profiles on interface.

Note: For untagged traffic forwarded via port based virtual circuits (service template with match-all option), queue will be 0 by default. In order to assign a non-zero queue for untagged traffic, use 'qos untagged-priority <0-7>' command on the interface.

Note: QoS profile queue-color-to-cos will take effect when MPLS model is uniform. For virtual circuit without rewrite option, 'qos remark-cos' need to be additionally configured to update cos. For virtual circuits with rewrite action pop, cos will always be updated based on qos profile irrespective of the MPLS model.

Command Syntax

```
mpls-l2-circuit NAME service-template NAME ({cos-to-queue NAME | queue-color-to-cos
  NAME}|) ((primary|secondary)|)
no  mpls-l2-circuit NAME
```

Parameters

`NAME`	A string identifying the MPLS Layer-2 Virtual Circuit
`primary`	Identify L2 circuit as the primary link
`secondary`	Identify L2 circuit as the secondary link; the secondary link is not activated unless the primary link fails
`service-template`	Customer service template
`NAME`	Name of Customer service template
`cos-to-queue`	Profile for cos to queue map
`NAME`	Profile name for cos to queue map
`queue-color-to-cos`	Profile for queue color to cos map
`NAME`	Profile name for queue color to cos map

Default

By default, mpls l2-circuit is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal

(config)#interface eth1
(config-if)#switchport
(config-if)#mpls-l2-circuit vc1 service-template C1

(config-if)#no mpls-l2-circuit vc1

(config)#interface eth2
(config-if)#switchport
(config-if)#mpls-l2-circuit vc2 service-template C2

(config-if)#no mpls-l2-circuit vc2

(config-if)#mpls-l2-circuit vc2 service-template C2
(config-if)#no mpls-l2-circuit vc2

(config)#interface eth2
(config-if)#switchport
(config-if)#mpls-l2-circuit vc2 service-template C2

(config-if)#no mpls-l2-circuit vc2

(config-if)#mpls-l2-circuit vc2 service-template C2
(config-if)#no mpls-l2-circuit vc2
```

mpls l2-circuit-fib-entry

Use this command to add a static Layer-2 MPLS Virtual Circuit FIB entry.

Use the `no` parameter with this command to delete a Layer-2 MPLS Virtual Circuit FIB entry.

Command Syntax

```
mpls l2-circuit-fib-entry <1-4294967295> <16-15999> <16-15999> (A.B.C.D|X:X::X:X)
  IFNAME NAME

no mpls l2-circuit-fib-entry <1-4294967295> (A.B.C.D|X:X::X:X)
```

Parameters

fib-entry <1-4294967295>	The Virtual Circuit ID ranges from 1 to 4294967295.
fib-entry <16-15999>	Incoming label in the range of <16-1048575>
fib-entry <16-15999>	Outgoing label in the range of <16-1048585>
fib-entry A.B.C.D	Nexthop IPv4 address
fib-entry X:X::X:X	Nexthop IPv6 address
fib-entry IFNAME	Provider-facing interface name
fib-entry NAME	Name of the access interface or the connecting VC.

Default

Disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit-fib-entry 10 100 200 10.10.10.10 eth1 eth2

#configure terminal
(config)#no mpls l2-circuit-fib-entry 10 10.10.10.10
```

mpls label mode

Use this command to configure label allocation mode for VPNv4 and/or VPNv6 routes. Label allocation mode as per-vrf is the default mode in which single mpls-label is allocated for all VPN Routes in a VRF. Label allocation mode as per-prefix will allocate unique mpls-labels per VPN route in a VRF. If allocation model is disabled using no mpls label mode configuration, the configuration reverts back to default-mode .

Label allocation mode is the local property i.e. the VRF routes are distributed to BGP-peer as per the mode configured on local node. When per-vrf mode is configured, single label for all routes in the VRF will be distributed to peer node.

Label allocation mode can be set for all VRFs or selective VRFs by these commands:

```
mpls label mode vpnv4 all-vrfs per-vrf
```

- If the admin selects the per-vrf mode for the entire system, then all VRFs switches to per-vrf allocation mode except for the VRFs that has been explicitly configured using command mpls label mode vpnv4 vrf WORD per-prefix. Label allocation mode set using specific VRF takes precedence over all-vrf command.

```
mpls label mode vpnv6 vrf WORD per-vrf
```

- If the admin selects per-vrf mode for a particular vrf say vrf1, then only vrf1 switches to per-vrf mode and rest of the vrfs will remain in default allocation mode.

Note: The CLI requires an explicit `clear ip bgp` command to observe the impact of the mode change in the Route Reflector (RR) or ASBR context. However, in the PE node role, the change is applied automatically. For RR/ASBR node roles, a manual trigger is necessary.

Command Syntax

```
mpls label mode (vpnv4|vpnv6|all-afs) (all-vrfs|vrf WORD) (per-prefix|per-vrf)
no mpls label mode (vpnv4|vpnv6|all-afs) (all-vrfs|vrf WORD) (per-prefix)


mpls label mode 6pe per-prefix
no mpls label mode 6pe per-prefix
```

Parameters

`vrf WORD`	Enter a string to identify the VRF
`all-vrfs`	All the VRFs
`per-prefix`	Unique MPLS labels are allocated per VPN route in a VRF
`per-vrf`	Single MPLS labels are allocated for all VPN routes in a VRF
`all-afs`	All the address families

Default

By default, per-vrf is enabled.

Command Mode

Configuration mode

Applicability

This command was introduced before OcNOS version 3.0.

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Example

```
#configure terminal
(config)#mpls label mode all-afs all-vrfs per-vrf

(config)#no mpls label mode all-afs all-vrfs

(config)#mpls label mode 6pe per-prefix

(config)#no mpls label mode 6pe per-prefix
```

mpls local-packet-handling

Use this command to enable the labeling of locally generated TCP packets. All other locally generated packets are not looked at by the MPLS Forwarder

Use the `no` parameter with this command to disable labeling of locally generated TCP packets.

Command Syntax

```
mpls local-packet-handling
no mpls local-packet-handling
```

Default

By default, mpls local packet handling is disabled

Parameters

None

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls local-packet-handling
```

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mpls lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when dscp is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the no parameter with this to unconfigure DSCP preserve.

Command Syntax

```
mpls lsp-encap-dscp-preserve
no mpls lsp-encap-dscp-preserve
```

Default

By default, mpls local packet handling is disabled

Parameters

None

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 6.5.2.

Examples

```
#configure terminal
(config)#mpls lsp-encap-dscp-preserve
(config)#commit
#configure terminal
(config)#no mpls lsp-encap-dscp-preserve
(config)#commit
```

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mpls lsp-model uniform

Use this command to configure the MPLS LSP model as uniform.

Use the `no` parameter with this command to configure the MPLS LSP model as pipe or short-pipe.

Command Syntax

```
mpls lsp-model uniform
no mpls lsp-model uniform
```

Parameter

None

Default

By default, model configuration is pipe for XGS devices.

Qumran devices have the following default behavior:

- For L3VPN services, model is short-pipe by default and pipe model can be set by configuring policy-maps with match exp and set queue.
- For L2VPN services, short-pipe model is not supported and the default model is pipe.
- For L2VPN services with rewrite action pop, cos value will always be updated from qos profile irrespective of model.
- For L2VPN services without rewrite, uniform model command does not take effect until 'qos remark-cos' is configured on egress interface.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls lsp-model uniform
(config)#exit

#configure terminal
(config)#no mpls lsp-model uniform
(config)#exit
```

mpls lsp-stitching

Use this command to stitch the LSP segment for an FEC created via a different label signaling protocol.

Use the `no` form of this command to disable this configuration.

Command Syntax

```
mpls lsp-stitching
no mpls lsp-stitching
```

Parameters

None

Default

By default, MPLS LSP stitching is disabled.

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 3.0.

Command Example

```
#configure terminal
(config)#mpls lsp-stitching
```

mpls map-route

Use this command to map a prefix to an FEC.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
mpls map-route (A.B.C.D/M|A.B.C.D A.B.C.D) (A.B.C.D/M|A.B.C.D A.B.C.D)
no mpls map-route (A.B.C.D/M|A.B.C.D A.B.C.D)
```

Parameters

`A.B.C.D`	IPv4 prefix to map
`A.B.C.D/M`	IPv4 prefix to map, plus mask
`A.B.C.D`	Mask for IPv4 prefix to map
`A.B.C.D/M`	Mask for IPv4 prefix to map, plus mask.
`A.B.C.D`	IPv4 forwarding equivalence class for route to map
`A.B.C.D`	Mask for IPv4 forwarding equivalence class

Default

By default, mpls map-route is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

In the following examples 5.6.7.8/32 is the FEC for an LSP, and 1.2.3.4 is the prefix to be mapped.

```
#configure terminal
(config)#mpls map-route 1.2.3.4/32 5.6.7.8/32

#configure terminal
(config)#mpls map-route 1.2.3.4 255.255.255.255 5.6.7.8 255.255.255.255
```

mpls min-label-value

Use this command to configure minimum and maximum label value for a label space. Use module names (rsvp | ldp | bgp) to configure minimum and maximum label value for module in a label space, minimum and maximum label space value for a module should be within the range of label space being used. After setting minimum and maximum label value for a label space, make sure to bind the label space to an interface.

Use the `no` parameter with this command to use the default minimum and maximum label value for all the label pools.

Note: The system allows label-space range (maximum and minimum label values) changes for interface-specific label spaces only. The platform-wide label-space range cannot be modified.

Note: Only label-space 0 (global) is supported. Any label-space other than 0, is not supported.

Command Syntax

```
mpls (rsvp|ldp|bgp|) min-label-value <16-1048575> max-label-value <16-1048575>
  (label-space <0-60000>|)
```

```
no mpls min-label-value max-label-value (label-space <0-60000>|)
```

```
no mpls (rsvp|ldp|bgp) (label-space <0-60000>|))
```

Parameters

`rsvp`	Label range value for RSVP
`ldp`	Label range value for LDP
`bgp`	Label range value for BGP
`min-label-value`	Specify the minimum label value
`<16-1048575>`	Minimum size to be used for label pools or protocol range
`max-label-value`	Specify the maximum label value
`<16-1048575>`	Maximum size for all label pools
`label-space`	Label space for which the minimum value needs to be modified
`<0-60000>`	Range for label space

Default

By default, mpls min-label value is 16

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls min-label-value 50000 max-label-value 80000 label-space 0
```

mpls propagate-ttl

Use this command to enable TTL propagation. Enabling TTL propagation causes the TTL value in the IP header to be copied onto the TTL field in the shim header, at the LSP ingress.

Use the `no` parameter with this command to disable TTL propagation.

Command Syntax

```
mpls propagate-ttl
no mpls propagate-ttl
```

Parameters

None

Default

By default, TTL propagation is disabled.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls propagate-ttl

#configure terminal
(config)#no mpls propagate-ttl
```

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mpls traffic-eng srlg

Use this command to create a Shared Risk Link Group (SRLG). An SRLG uses secondary backup LSPs or Fast Reroute bypass/detour LSPs that minimize the probability of "fate sharing" with the path of the primary LSP.

Use the `no` form of this command to remove an SRLG.

Note:

- An interface can be part of multiple SRLG groups upto a maximum of 255 SRLG groups.
- Any addition or deletion of SRLG value on an interface will not recalculate Primary/Backup. It is advised to configure SRLG values before bringing UP RSVP sessions or clear rsvp sessions after updating SRLG values.

Command Syntax:

```
mpls traffic-eng srlg <0-4294967295>
no mpls traffic-eng srlg <0-4294967295>
```

Parameters

`<0-4294967295>` Risk group number

Command Mode

Interface mode

Example

```
#configure terminal
(config)#int eth1
(config-if)#mpls traffic-eng srlg 1
```

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pce entity

Use this command to:

- Assign a PCE entity to a segment routing policy
- Assign a PCE entity to a RSVP tunnel

Use the `no` form of this command to:

- Remove a PCE entity from a segment routing policy
- Remove a PCE entity from a RSVP tunnel

Syntax

```
pce entity <1-255>
no pce entity
```

Parameters

`entity <1-255>`	Path computation element entity identifier.

Command Mode

RSVP trunk mode

Segment routing policy mode

Applicability

Introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#rsvp-trunk T1 ipv4
(config-trunk)#pce entity 127

#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy P1
(config-sr-pol)#pce entity 127
```

pce lsp-delegate

Use this command to delegate all LSPs of a segment routing policy or RSVP trunk to a PCE entity.

Use `no` form of this command to revoke all LSPs of a segment routing policy or RSVP trunk from a PCE entity.

Syntax

```
pce lsp-delegate
no pce lsp-delegate
```

Parameters

None

Default

LSPs are not delegated to a segment routing policy of RSVP trunk.

Command Mode

RSVP trunk mode

Segment routing policy mode

Applicability

Introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy P1
(config-sr-pol)#pce lsp-delegate

#configure terminal
(config)#rsvp-trunk T1 ipv4
(config-trunk)#pce lsp-delegate
```

pce state-report

Use this command to enable sending a PCEP state report.

Use the `no` form of this command to disable sending a PCEP state report.

Syntax

```
pce state-report
no pce state-report
```

Parameters

None

Default

Sending a PCEP state report is disabled.

Command Mode

RSVP trunk mode

Segment routing policy mode

Applicability

Introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy P1
(config-sr-pol)#pce state-report

#configure terminal
(config)#rsvp-trunk T1 ipv4
(config-trunk)#pce state-report
```

ping mpls

Use this command to start sending MPLS request packets using various parameters as defined below. Ping packets can be configured for LDP, RSVP, L2 circuit, VPLS, L3 VPN, Segment Routing or generic FEC types.

Command Syntax

```
ping mpls (ldp A.B.C.D/M|rsvp (tunnel-name NAME|egress A.B.C.D)|l2-circuit <1-
  4294967295> peer A.B.C.D/M |vpls <1-10000> peer A.B.C.D/M|l3vpn VRFNAME A.B.C.D/M
  |ipv4 A.B.C.D/M) ({reply-mode (1|2)|flags|destination A.B.C.D|source A.B.C.D|ttl
  <1-255>|timeout <1-500>|repeat <5-5000>|interval <2-20000>|force-explicit-
  null|detail}|)

ping mpls (l3vpn (VRFNAME A.B.C.D/M X:X::X:X/M source A.B.C.D destination A.B.C.D))
  ({timeout <1-500>|ttl <1-255>|repeat <5-5000>|interval <2-20000>|detail}|)

ping mpls (6pe default X:X::X:X/M source A.B.C.D destination A.B.C.D)) ({timeout
  <1-500>|ttl <1-255>|repeat <5-5000>|interval <2-20000>|detail}|)

ping mpls (| protocol-origin (local | pcep) )(sr-policy SR_POLICY_NAME (|
  candidate-path CANDIDATE_PATH_ID))({flags|source A.B.C.D | ttl <1-255> | timeout
  <1-500> | repeat <5-5000>|interval <2-20000> | force-explicit-null | detail}|)

ping mpls  (ospf-sr | isis-sr)(ipv4 A.B.C.D/M )({reply-mode (1|2|3)|flags |
  destination A.B.C.D|source A.B.C.D | ttl <1-255> | timeout <1-500> | repeat <5-
  5000>|interval <2-20000> | force-explicit-null | detail}|)
```

Parameters

`ldp`	FEC type is LDP
`A.B.C.D/M`	LDP prefix address
`rsvp`	FEC type is RSVP
`tunnel-name`	RSVP tunnel name
`NAME`	Tunnel name string
`egress`	RSVP tunnel egress
`A.B.C.D`	RSVP tunnel egress address
`l2-circuit`	FEC type is L2 circuit
`<1-4294967295>`	L2 circuit ID
`peer A.B.C.D/M`	IP address of the peer
`vpls`	FEC type is MPLS VPLS (L2-VPN)
`<1-10000>`	VPLS instance ID
`peer`	VPLS peer
`A.B.C.D/M`	VPLS peer address
`l3vpn`	FEC type is MPLS VPN (L3-VPN)
`VRFNAME`	VPN instance name
`A.B.C.D./M`	VPN prefix

`X:X::X:X/M`	VPNv6 prefix
`6pe`	FEC type (6PE)
`default`	VPN Instance Name (default)
`X:X::X:X/M`	6PE Prefix
`ipv4`	FEC type is generic; use for static/SNMP label switched paths
`A.B.C.D/M`	IPv4 prefix address
`Protocol-origin`	Protocol origin for SR policy
`Local`	local originated sr policy
`Pcep`	Pcep orginated SR policy
`SR policy`	SR policy ping
`SR_POLICY_NAME`	Policy name
`Candidate-path`	Candidate path
`CANDIDATE_PATH_ID`	Candidate path id
`reply-mode`	Reply mode, one of
`1`	Do not reply
`2`	Reply via UDP/IP packet (default)
`flags`	Validate FEC stack
`destination`	Destination address
`A.B.C.D`	IPv4 address of the destination
`source`	Source address
`A.B.C.D`	IPv4 address of the source
`ttl`	Trace packet Time-to-live
`<1-255>`	Trace packet TTL value
`repeat`	Repeat sending of ping packets
`<5-5000>`	Number of pings to send
`interval`	Interval between ping packets, in milliseconds
`<2-20000>`	Interval value
`timeout`	Time to wait before rejecting the probe as a failure, in seconds
`<1-500>`	Timeout value
`force-explicit-null`	Force Explicit NULL label
`detail`	Print detailed output of the ping

Defaults

Default TTL value is 255.

Default timeout value is 60 seconds.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3. The SR ping command was introduced in OcNOS version 4.1.

Example

```
#ping mpls ipv4 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls l2-circuit 3 peer 192.0.2.0/32 reply-mode 2 flags destination 127.1.3.4
source 10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls l3vpn vrfa 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls ldp 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls rsvp egress 1.2.3.5 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls rsvp tunnel-name tun1 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

#ping mpls vpls 2 peer 10.10.0.0 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 ttl 226 timeout 65 repeat 6 interval 3 detail force-explicit-null

# ping mpls sr-policy LSP3_R1_R4_R2 detail
# ping mpls ospf-sr ipv4 2.2.2.2/32 detail
# ping mpls isis-sr ipv4 2.2.2.2/32 detail

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

! seq_num = 1 200.0.0.1 2.02 ms
! seq_num = 2 200.0.0.1 2.00 ms
! seq_num = 3 200.0.0.1 1.93 ms
! seq_num = 4 200.0.0.1 2.14 ms
! seq_num = 5 200.0.0.1 1.78 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.78/1.96/2.14
```

rewrite ingress

Use this command to configure a match VLAN action for a service template.

Use the `no` parameter with this command to remove a match VLAN action for a service template.

Command Syntax

```
rewrite ingress (((pop |translate <2-4094>)(|outgoing-tpid (dot1.ad |dot1.q)))|
  (push <2-4094>))

no rewrite ingress (pop |push |translate)
```

Parameters

`pop`	POP the outer VLAN identifier from ACCESS->NETWORK and PUSH the match outer VID to NETWORK->ACCESS
`translate`	Translate the outer VLAN identifier to configured action VID for ACCESS->NETWORK and translate to the match outer VID for NETWORK->ACESS
`<2-4094>`	Outer VLAN identifier
`outgoing-tpid`	Outgoing TPID, set the outer-tpid for the NETWORK->ACCESS
`dot1.ad`	Set TPID value as 0x88a8 for the traffic NETWORK->ACCESS
`dot1.q`	Set TPID value as 0x8100 for the traffic NETWORK->ACCESS
`push`	PUSH the outer VLAN identifier from ACESS->NETWORK and POP the Outer VID from NETWORK->ACCESS
`<2-4094>`	Outer VLAN identifier

Command Mode

MPLS SVC mode

Applicability

This command was introduced in OcNOS version 1.3.3, and changed in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#service-template C2
(config-svc)#match double-tag outer-vlan 9 inner-vlan 8
(config-svc)#rewrite ingress translate 7 outgoing-tpid dot1.ad
(config-svc)#exit

(config)#service-template C2
(config-svc)#no rewrite ingress translate
(config-svc)#exit
```

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secondary srlg-disjoint

Use this command to set how to avoid the SRLGs (Shared Risk Link Groups) of a protected primary.

A fast-reroute/secondary path for an LSP that is disjoint from the primary ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Note: The SRLG option configured in RSVP-TRUNK mode (this command) takes higher preference than the option configured in RSVP router mode (see 'srlg-disjoint').

Use the `no` form of this command to not avoid the SRLGs of a protected interface.

Command Syntax

```
secondary srlg-disjoint (forced|preferred)
no secondary srlg-disjoint
```

Parameters

`forced`	The router does not create the secondary/backup tunnel unless it avoids SRLGs of the primary-path/protected-interface.
`preferred`	With two explicit paths, the first explicit path tries to avoid the SRLGs of the primary-path/ protected interface. If that does not work, the secondary/backup tunne uses the second path (which ignores SRLGs).

Command Mode

RSVP -TRUNK mode

Example

```
#configure terminal
(config)#rsvp-trunk t1
(config-rsvp)# secondary srlg-disjoint forced
```

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secondary-priority srlg-disjoint

Use this command to set how to avoid the SRLGs (Shared Risk Link Groups) of a protected primary.

A fast-reroute/secondary path for an LSP that is disjoint from the primary ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Note: The SRLG option configured in RSVP-TRUNK mode (this command) takes higher preference than the option configured in RSVP router mode (see the srlg-disjoint command).

Use the `no` form of this command to not avoid the SRLGs of a protected interface.

Command Syntax

```
secondary-priority <1-5> srlg-disjoint (forced|preferred)
no secondary-priority <1-5> srlg-disjoint
```

Parameters

`forced`	The router does not create the secondary/backup tunnel unless it avoids SRLGs of the primary-path/protected-interface.
`preferred`	With two explicit paths, the first explicit path tries to avoid the SRLGs of the primary-path/ protected interface. If that does not work, the secondary/backup tunnel uses the second path (which ignores SRLGs).

Command Mode

RSVP -TRUNK mode

Example

```
#configure terminal
(config)#rsvp-trunk t1
(config-rsvp)# secondary-piority 1 srlg-disjoint forced
```

service-tpid

Use this command to configure service tpid for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete service tpid from the MPLS layer-2 virtual circuit.

Command Syntax

```
service-tpid (dot1.q|dot1.ad|0x9100)
no service-tpid
```

Parameters

`0x9100`	Set tpid value as 0x9100
`dot1.ad`	Set tpid value as 0x88a8
`dot1.q`	Set tpid value as 0x8100

Default

By default, service-tpid is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#service-tpid dot1.ad
```

service-template

Use this command to configure a service template.

Use no form of this command to remove a service template.

Command Syntax

```
service-template NAME
no service-template NAME
```

Parameters

NAME	Name of the customer service template

Defaults

No default value is specified

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 1.3.3.

Examples

```
#configure terminal
(config)#service-template C1
(config-svc)#
```

show mpls

Use this command to display MPLS data.

Command Syntax

```
show mpls
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following subsection displays a variety of `show mpls` commands.

```
#show mpls
Minimum label configured: 16
 Maximum label configured: 1048575
 Per label-space information:
   Label-space 0 is using minimum label: 16 and maximum label: 1048575
   Label-space 2342 is using minimum label: 556 and maximum label: 1048575
 Custom ingress TTL configured: none
 Custom egress TTL configured: none
 Log message detail: none
 Admin group detail: none
 Packets dropped IP:115167, dropped MPLS:0 sent to IP:490943, labeled:0,
switch
d:0

MPLS Differentiated Services Supported Classes data:
CLASS        DSCP_value
  be            000000

MPLS Differentiated Services CLASS to EXP mapping data:
CLASS     DSCP_value     EXP_value
  be       000000           0
#
```

Table 1 explains the show command output fields.

Table 1: show mpls output field

Field	Description
Packets dropped IP	Displays the number of packets dropped over the internet protocol.
Dropped MPLS	Displays the number of packets dropped over the MPLS.

Table 1: show mpls output field

Field	Description
Sent to IP	Displays the number of packets transmitted to the internet protocol.
Labeled	Number of labeled packets in the interface. The MPLS-labeled packets are switched after a label lookup/switch instead of a lookup into the IP table. Labels of pop-and-forward mpls tunnel: P—Pop labels. D—Delegation labels.
Switch	Type of switching on the links needed for the MPLS.
Class	Creates a class map to be used for matching traffic to a specified class, and enters class-map configuration mode.
DSCP Value	The value of the DSCP and DSCP classifier is used for routing Layer 3 packets.
EXP value	Sets the value of the MPLS EXP field on all imposed label entries.

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show admin-groups

Use this command to display all configured administrative groups.

Command Syntax

```
show admin-groups
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following sample shows the output of the `show admin-group` command.

```
#show admin-groups
 Admin group detail:
  Value of 0 associated with admin group 'a'
  Value of 1 associated with admin group 'b'
  Value of 2 associated with admin group 'c'
  Value of 4 associated with admin group 'd'
#
```

Table 2 explains the show command output fields.

Table 2: show admin-groups output field

Field	Description
Admin group detail	Display information about configured Multi Protocol Label Switching (MPLS) administrative groups.

show mpls bandwidth-class

Use this command to view bandwidth class parameters: bandwidth class name; allocated bandwidth; setup hold priority

Command Syntax

```
show mpls bandwidth-class
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
> show mpls bandwidth-class
Bandwidth-class: BW_1
Bandwidth:   6k        Setup-priority: 1  Class-type: 1
```

Table 3 explains the show command output fields.

Table 3: show mpls bandwidth-class output field

Field	Description
Bandwidth-class	Bandwidth for each class type.
Bandwidth	Bandwidth configured for the active MPLS.
Setup-Priority	The setup priority is compared with other setup priorities for established sessions on the link to determine whether some of them should be preempted to accommodate the new session. Sessions with lower hold priorities are preempted.
Class-type	Bandwidth allocated for the specified class type.

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show mpls counters ldp

Use this command to display traffic statistics for FTNs and ILMs configured by LDP.

Command Syntax

```
show mpls counters ldp ((ftn (|A.B.C.D/M)) | (ilm (|A.B.C.D/M)) |)
```

Parameter

`ftn`	FEC-to-NHLFE map counters
`A.B.C.D/M`	FEC prefix
`ilm`	Incoming label map counters
`A.B.C.D/M`	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.2.

Note: For Qumran, counters are not available for transit nodes.

Examples

```
OcNOS#show mpls counter ldp
[FTN statistics]
+------------------+-----+----------+-----------+------------+----------------+-------------------+--------------------+
|       FEC        | Pri | nhlfe_ix | out-label |  out-intf  |     nexthop    |    Tx packets     |       Tx bytes     |
+------------------+-----+----------+-----------+------------+----------------+-------------------+--------------------+
 4.4.4.4/32         1     1          3           xe3          10.10.1.2       62                   4484

[ILM statistics]
+------------------+-----------+-----------+--------------------+--------------------+--------------------+----------------+
|       FEC        | in-label  | out-label |     Rx packets     |      Rx bytes      |     Tx packets     |     Tx bytes   |
+------------------+-----------+-----------+--------------------+--------------------+--------------------+----------------+
```

Table 4 explains the show command output fields.

Table 4: show mpls counters ldp output field

Field	Description
FTN statistics	Displays the statistics details of FTN.
ILM statistics	Displays the statistics details of ILM.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-label	Displays the egress (outgoing interface) label for this segment.
Rx packets	Number of hello packets received from the neighbor.
Rx bytes	Size of hello packets received from the neighbor.

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Table 4: show mpls counters ldp output field

Field	Description
Tx packets	Number of hello packets sent to the neighbor.
Tx bytes	Size of hello packets sent to the neighbor.

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show mpls counters rsvp

Use this command to display traffic statistics for LSPs configured by RSVP.

Command Syntax

```
show mpls counters rsvp ((tunnel-name NAME) | (tunnel-id TUNNEL_ID) | (node-role
  (ingress | transit | egress)) |)
```

Parameter

NAME	RSVP tunnel name
TUNNEL_ID	RSVP tunnel identifier
ingress	LSP role is ingress
transit	LSP role is transit
egress	LSP role is egress

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.2.

Note: For Qumran, counters are not available for transit nodes.

Examples

```
#show mpls counters rsvp
Tunnel-id 5001 Extended Tunnel-ID 9.9.9.1 Egress 9.9.9.2
 lsp-name : t1-Primary                                  [Ingress]
 lsp-ingress : 9.9.9.1         lsp-id : 101
 Rx pkts : 0                   Rx bytes : 0
 Tx pkts : 0                   Tx bytes : 0

 lsp-name : t1-Secondary                                [Ingress]
 lsp-ingress : 9.9.9.1         lsp-id : 102
 Rx pkts : 0                   Rx bytes : 0
 Tx pkts : 0                   Tx bytes : 0

Tunnel-id 5002 Extended Tunnel-ID 9.9.9.1 Egress 9.9.9.3
 lsp-name : t2-Primary                                  [Ingress]
 lsp-ingress : 9.9.9.1         lsp-id : 104
 Rx pkts : 0                   Rx bytes : 0
 Tx pkts : 0                   Tx bytes : 0

 lsp-name : t2-Detour                                   [Ingress]
 lsp-ingress : 1.1.49.1        lsp-id : 104
 Rx pkts : 0                   Rx bytes : 0
 Tx pkts : 0                   Tx bytes : 0
```

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Table 5 explains the show command output fields.

Table 5: show mpls counters rsvp output field

Field	Description
Tunnel-id	Tunnel identifier (destination port) for the RSVP session.
Extended Tunnel-ID	Extended Tunnel identifier (destination port) for the RSVP session.
Egress	Egress router is the final MPLS device that removes the last label before packets leave the MPLS network.
lsp-name	Name of the SPRING-TE LSP.
Ingress	The router at the beginning of an LSP. This router encapsulates IP packets with an MPLS Layer 2 frame and forwards it to the next router in the path.
lsp-ingress	The router at the beginning of an LSP.
lsp-id	Specify the generic LSP identifier.
Rx packets	Number of hello packets received from the neighbor.
Rx bytes	Size of hello packets received from the neighbor.
Tx packets	Number of hello packets sent to the neighbor.
Tx bytes	Size of hello packets sent to the neighbor.

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show mpls counters static

Use this command to display traffic statistics for statically configured FTNs and ILMs.

Command Syntax

```
show mpls counters static ((ftn (A.B.C.D/M|)) | (ilm (A.B.C.D/M|)) |)
```

Parameter

`ftn`	FEC-to-NHLFE map counters
`A.B.C.D/M`	FEC prefix
`ilm`	Incoming label map counters
`A.B.C.D/M`	FEC prefix

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.2.

Note: For Qumran, counters are not available for transit nodes.

Examples

```
#show mpls counters static
[ FTN statistics ]
+------------------+-----------+--------------------+--------------------+
|       FEC        | out-label |     Tx packets     |      Tx bytes      |
+------------------+-----------+--------------------+--------------------+
 192.168.1.0/24     100         0                    0
 192.168.2.0/24     200         0                    0

[ ILM statistics ]
+------------------+-----------+-----------+--------------------+--------------------+--------------------+----------------+
|       FEC        | in-label  | out-label |     Rx packets     |      Rx bytes      |     Tx packets     |      Tx bytes  |
+------------------+-----------+-----------+--------------------+--------------------+--------------------+----------------+
 0.0.0.0/0          201         n/a         0                    0                    n/a                  n/a
 0.0.0.0/0          101         n/a         0                    0                    n/a                  n/a
 192.168.3.0/24     301         302         0                    0                    0                    0
 192.168.4.0/24     401         402         0                    0                    0                    0
#
```

Table 6 explains the show command output fields.

Table 6: show mpls counters static output field

Field	Description
FTN statistics	Displays the statistics details of FTN.
ILM statistics	Displays the statistics details of ILM.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
In-label	Displays the ingress (incoming interface) label for this segment.

Table 6: show mpls counters static output field

Field	Description
Out-label	Displays the egress (outgoing interface) label for this segment.
Rx packets	Number of hello packets received from the neighbor.
Rx bytes	Size of hello packets received from the neighbor.
Tx packets	Number of hello packets sent to the neighbor.
Tx bytes	Size of hello packets sent to the neighbor.

show mpls cross-connect-table

Use this command to display detailed information for all entries created in the MPLS cross-connect table.

Command Syntax

```
show mpls cross-connect-table
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output of the show mpls cross-connect-table

```
#show mpls cross-connect-table
  Cross connect ix: 3, in intf: -, in label: 0, out-segment ix: 3
    Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
   Out-segment with ix: 3, owner: RSVP, out intf: eth1, out label: 16
    Nexthop addr: 10.10.20.80, cross connect ix: 3, op code: Push

  Cross connect ix: 6, in intf: -, in label: 0, out-segment ix: 6
    Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
   Out-segment with ix: 6, owner: RSVP, out intf: eth1, out label: 17
    Nexthop addr: 10.10.20.80, cross connect ix: 6, op code: Push
#
```

Table 7 explains the show command output fields.

Table 7: show mpls cross-connect-table output field

Field	Description
Cross connect ix	Displays the table index for the cross-connect.
In intf	Installed as a result of configuring an interface.
In label	Displays the ingress (incoming interface) label for this segment.
Out-segment ix	Displays the outbound segment index.
Owner	Displays the creator of this segment, typically a protocol such as BGP.
Persistent	Displays whether the tunnel is persistent – Yes or No.
Admin Status	Indicates whether the user can administratively disable a peer while still preserving its configuration. Up = Yes, Down = No.

Table 7: show mpls cross-connect-table output field

Field	Description
Oper Status	Displays the current status of the cross-connect segment – Up or Down
Nexthop addr	Displays the IP address of the next hop.
Op code	PUSH = Replace the top label with another and then push one or more additional labels onto the label stack SET = Set the next hop label.

show mpls cross-connect-table backup

Use this command to display detailed information for all entries created in the MPLS backup cross-connect table.

Command Syntax

```
show mpls cross-connect-table backup
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mod

Applicability

This command is newly introduced in OcNOS version 5.1.

Example

The following is a sample output of the show mpls cross-connect-table backup

```
#show mpls cross-connect-table backup

Backup Cross connect ix: 4, in intf: - in label: 0  out-segment ix: 17
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 17, owner: LDP, Stale: NO, out intf: xe3, out label: 24324
Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push
Primary xc-ix 2 out-segment ix 17


Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 12
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe21, out label: 24320
Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push
Primary xc-ix 2 out-segment ix 17
```

show mpls forwarding-table detail

Use this command to view forwarding table entries.

Command Syntax

```
show mpls forwarding-table ((A.B.C.D/M|X:X::X:X/M|) | count | detail |)
```

Parameters

`A.B.C.D/M`	FEC IPv4
`X:X::X:X/M`	FEC IPv6
`count`	Count of IPv4 FTNs.
`detail`	show detail

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and the detail option is applicable form OcNOS version 4.2.

Detail applicable form is modified to display backup information if present (only for LDP FTNs).

Example

If LFA flag is not enabled

```
#show mpls forwarding-table detail

FEC prefix: 41.41.41.41/32, FTN-ID: 5
  Owner: LDP, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 7
  Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No
```

If LFA is enabled and backup not present:

```
FEC prefix: 41.41.41.41/32, FTN-ID: 5
  Owner: LDP, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 7
  Primary : Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No
```

If Backup is present:

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```
#show mpls forwarding-table detail
FEC prefix: 10.10.10.0/24, FTN-ID: 2
  Owner: LDP, FTN type: Regular, State: Installed
  Tunnel-Name: N/A, Tunnel-id: N/A, Color: N/A
  LSP-ID: N/A, LSP-type: Primary
  NHLFE-id: 4
  Primary : Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  LFA Backup  : Out-Label: 3, Out-Intf: xe3, Nexthop: 20.20.20.1
  Primary : Out-Label: 3, Out-Intf: xe3, Nexthop: 20.20.20.1
  LFA Backup  : Out-Label: 3, Out-Intf: xe1, Nexthop: 50.50.50.1
  Exp-bits: 0x0, Incoming DSCP: none, QoS Resource id: 0
  ELC: No
```

show mpls forwarding-table

Use this command to view forwarding table entries.

Command Syntax

```
show mpls forwarding-table ((A.B.C.D/M|X:X::X:X/M|) | count | detail |)
```

Parameters

`A.B.C.D/M`	FEC IPv4
`X:X::X:X/M`	FEC IPv6
`count`	Count of IPv4 FTNs.
`detail`	Show detail

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and the `detail` parameter added in OcNOS version 4.2. The output was extended to display backup Information as well.

Example

If Backup not present:

```
#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code FEC            FTN-ID  Nhlfe-ID  Tunnel-id  Pri  LSP-Type     Out-Label Out-Intf   ELC   Nexthop
L>   10.10.10.0/24  2       4         -          Yes  LSP_DEFAULT  3         xe1        No    50.50.50.1
                            -                    Yes  LSP_DEFAULT  3         xe3        No    20.20.20.1
   L>   30.30.30.0/23       3         5         -          Yes   LSP_DEFAULT  3           xe1         No    50.50.50.1
   L>   30.30.30.0/24       1         2         -          Yes   LSP_DEFAULT  3           xe6         No    40.40.40.2
   L>   35.35.35.35/32      5         7         -          Yes   LSP_DEFAULT  3           xe6         No    40.40.40.2
   L>   41.41.41.41/32      4         6         -          Yes   LSP_DEFAULT  3           xe1         No    50.50.50.1
   L>   44.44.44.44/32      6         11        -          Yes   LSP_DEFAULT  3           xe3         No    20.20.20.1
#
```

If Backup is present:

```
#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC                 FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label    Out-Intf    ELC    Nexthop
   L>   10.10.10.0/24       2         4         -           Yes   LSP_DEFAULT  3            xe1         No     50.50.50.1
                                                -           No    LSP_DEFAULT  3            xe3         No     20.20.20.1
                                                -           Yes   LSP_DEFAULT  3            xe3         No     20.20.20.1
                                                -           No    LSP_DEFAULT  3            xe1         No     50.50.50.1
   L>   30.30.30.0/23       3         5         -           Yes   LSP_DEFAULT  3            xe1         No     50.50.50.1
   L>   30.30.30.0/24       1         2         -           Yes   LSP_DEFAULT  3            xe6         No     40.40.40.2
```

```
L>   35.35.35.35/32      5         7         -          Yes   LSP_DEFAULT  3            xe6         No    40.40.40.2
L>   41.41.41.41/32      4         6         -          Yes   LSP_DEFAULT  3            xe1         No    50.50.50.1
L>   44.44.44.44/32      6         11        -          Yes   LSP_DEFAULT  3            xe3         No    20.20.20.1
                                             -          No    LSP_DEFAULT  24326        xe1         No    50.50.50.1
L>   1.1.1.1/32          2         4         -          Yes   LSP_DEFAULT  24320        xe12        No    20.1.1.1
                                   11        -          No    LSP_DEFAULT  24320        xe5         No    30.1.1.1
                                   11        -          Yes   LSP_DEFAULT  24320        xe5         No    30.1.1.1
                                   3         -          No    LSP_DEFAULT  24320        xe12        No    20.1.1.1
L>   2.2.2.2/32          3         6         -          Yes   LSP_DEFAULT  3            xe12        No    20.1.1.1
                                   15        -          No    LSP_DEFAULT  24324        xe5         No    1.1.1.1
                                                                                        (via 30.1.1.1 ,label 24320)
L>   3.3.3.3/32          1         2         -          Yes   LSP_DEFAULT  3            xe5         No    30.1.1.1
                                   16        -          No    LSP_DEFAULT  24325        xe12        No    1.1.1.1
                                                                                        (via 20.1.1.1 ,label 24320)
```

show mpls ftn-table

Use this command to display FTN (FEC-To-NHLF) table information.

Command Syntax

```
show mpls ftn-table
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

If LFA is not present

```
#show mpls ftn-table

Primary FTN entry with FEC: 10.10.10.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.50.50.1        cross connect ix: 3, op code: Push
```

If Backup is present

```
#show mpls ftn-table
Primary FTN entry with FEC: 10.10.10.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.50.50.1        cross connect ix: 3, op code: Push


Backup Cross connect ix: 4, in intf: - in label: 0  out-segment ix: 8
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe3, out label: 3
Nexthop addr: 20.20.20.1        cross connect ix: 3, op code: Push
```

show mpls ilm-table

Use this command to view Incoming label mapping (ILM) table entries.

Command Syntax

```
show mpls ilm-table (count|)
```

Parameters

`count`	Count of entries in ILM table.

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown
ILM-ECMP LDP: Disabled, SR: Disabled
Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF       Nexthop                   pri  UpTime
  B>   RR/ASBR/6PE      32         26881      28801      N/A       N/A
1.1.1.1                Yes  00:02:23
  L>   3.3.3.3/32       4          25601      3          N/A       ge9
12.0.0.1               Yes  00:57:07
  L>   1.1.1.1/32       1          25600      3          N/A       ge11
11.0.0.1               Yes  00:58:48
  B>   RR/ASBR/6PE      31         26880      28800      N/A       N/A
1.1.1.1                Yes  00:02:23
  B>   RR/ASBR/6PE      33         26882      26880      N/A       N/A
3.3.3.3                Yes  00:02:22
  B>   RR/ASBR/6PE      34         26883      26881      N/A       N/A
3.3.3.3                Yes  00:02:22                        LSP_DEFAULT

#show mpls ilm-table count
--------------------------------------------
Num ILMs          : 6 [UP: 6, INSTALL: 6]
  Swap Entries    : 6 [UP: 6, INSTALL: 6]
--------------------------------------------
```

Table 8 shows the status codes displayed at the start of a route entry.

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Table 8: status code output field

Status Code	Field	Description
	Installed ILM	Number of ILM entry installed.
*	Selected ILM	ILM entry selected in the interface.
P	Stale ILM	Stale marked ILM due to on-going graceful restart of MPLS module.
K	CLI ILM	Admin configured static ILM entry.
T	MPLS-TP	ILM entry installed by MPLS-TP.

Table 9 explains the show command output fields.

Table 9: show mpls ilm-table output field

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
ILM-ID	ILM identifier for the session.
LSP-Type	LSP type associated with each interface being protected.
Out-Label	Label received from downstream neighbor for route.
Out-Intf	Short name of the physical interface through which traffic goes to the protected link.
In label	Displays the ingress (incoming interface) label for this segment.
In intf	Installed as a result of configuring an interface.
Nexthop	Displays the IP address of the next hop.
Num ILMs	Number of ILMs in the session.
Swap Entries	Number of packets in the entry.
Pop Entries	Number of POP entries.

show mpls in-segment-table

Use this command to display detailed information about all entries in the Incoming Label Map (also known as in-segment) table.

Command Syntax

```
show mpls in-segment-table
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls in-segment-table
  Owner: RSVP,#of pops: 1, fec: 192.168.0.5/32
    RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
LSP Type: ELSP_CONFIG
Class_Exp mapping:
CLASS    DSCP_value     EXP_value
  be      000000           0
     Cross connect ix: 1, in intf: eth0 in label: 52480 out-segment ix: 1
      Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: RSVP, out intf: eth1, out label: 52480
        Nexthop addr: 20.30.0.3        cross connect ix: 1, op code: Swap
     Cross connect ix: 1, in intf: eth0 in label: 52480 out-segment ix: 2
      Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: RSVP, out intf: eth2, out label: 52481
        Nexthop addr: 30.30.0.3        cross connect ix: 1, op code: Swap
#
```

Table 10 explains the show command output fields.

Table 10: show mpls in-segment-table output field

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
RX bytes	Size of hello packets received from the neighbor.
Pkts	Number packet in the interface.
TX bytes	Size of the packets that transmitted to the neighbor.
Swapped pkts	Number of swapped packets in session.

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Table 10: show mpls in-segment-table output field

Field	Description
Popped pkts	Number of popped packets in the interface.
LSP-Type	LSP type associated with each interface being protected.
CLASS	Creates a class map to be used for matching traffic to a specified class, and enters class-map configuration mode.
DSCP value	The value of the DSCP and DSCP classifier is used for routing Layer 3 packets.
EXP value	Sets the value of the MPLS EXP field on all imposed label entries.
Cross-connect ix	Displays the table index for the cross-connect.
Out-Label	Label received from downstream neighbor for route.
Out-Intf	Short name of the physical interface through which traffic goes to the protected link.
In label	Displays the ingress (incoming interface) label for this segment.
In intf	Installed as a result of configuring an interface.
Nexthop	Displays the IP address of the next hop.
Out-segment ix	Displays the outbound segment index.
Persistent	Displays whether the tunnel is persistent – Yes or No.
Admin Status	Indicates whether the user can administratively disable a peer while still preserving its configuration. Up = Yes, Down = No.
Oper Status	Displays the current status of the cross-connect segment – Up or Down.
Op code	PUSH = Replace the top label with another and then push one or more additional labels onto the label stack. SET = Set the next hop label.

show mpls l2-circuit

Use this command to view MPLS-TP L2 circuit parameters.

Command Syntax

```
show mpls l2-circuit (detail|)
show mpls l2-circuit NAME (detail|)
```

Parameters

`detail`	Show detailed information
`NAME`	The name of the virtual circuit

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: vc1, id: 1 PW-INDEX: 1 service-tpid: 8100

Endpoint: 1.1.1.1
Control Word: 0
MPLS Layer-2 Virtual Circuit Group: none
Bound to interface: xe41
Virtual Circuit Type: Ethernet VLAN
Virtual Circuit is configured as Primary
Virtual Circuit is configured as Active
Virtual Circuit is active
Service-template : C1
Match criteria : 10-14, 16-20
```

Table 11 explains the show command output fields.

Table 11: show mpls l2-circuit output field

Field	Description
MPLS Layer-2 Virtual Circuit	The MPLS virtual circuit on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.
Endpoint	Endpoint address.
Control Word	Number of control words.
MPLS Layer-2 Virtual Circuit Group	The MPLS virtual circuit group on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.

Table 11: show mpls l2-circuit output field

Field	Description
Bound to interface	A bound service is the server in a client-server interface.
Virtual Circuit Type	Type of virtual circuit in the interface.
Service-template	Service Templates provides a powerful mechanism to configure advanced service-related options.
Match criteria	The match criteria under which redistribution is allowed for the current route-map.

show mpls l2-circuit statistics

Use this command to display MPLS traffic statistics for l2 circuit.

Command Syntax

```
show mpls l2-circuit NAME statistics (access-port|network-port|)
```

Parameters

`NAME`	Name of L2 circuit
`access-port`	Displays the access port statistics
`network-port`	Displays the network port statistics

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls l2-circuit t1 statistics
MPLS Layer-2 Virtual Circuit: t1, id 100        # Virtual circuit name and ID
Access port statistics:
   RX: Input packets : 1000
       Input bytes : 120000
   TX: Output packets : 0
       Output bytes : 0
Network port statistics:
   RX: Input packets : 0
       Input bytes : 0
   TX: Output packets : 1000
       Output bytes : 120000
```

Table 12 explains the show command output fields.

Table 12: show mpls l2-circuit statistics output field

Field	Description
MPLS Layer-2 Virtual Circuit	The MPLS virtual circuit on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.
Virtual circuit name and ID	The MPLS virtual circuit identifier on the egress PE router or switch and the specified neighbor, testing the integrity of the Layer 2 circuit between the ingress and egress PE routers or switches.
Access port statistics	Traffic statistics on Access port of VC/VPLS.
Network port statistics	Traffic statistics on Provider port of VC/VPLS.
RX	Number of received packets.

Table 12: show mpls l2-circuit statistics output field

Field	Description
Input packets	Number of hello packets received from the neighbor.
Input bytes	Size of hello packets received from the neighbor.
TX	Number of packets transmitted.
Output packets	Number of hello packets sent to the neighbor.
Output bytes	Size of hello packets sent to the neighbor.

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show mpls mapped-routes

Use this command to view MPLS mapped routes.

Use the `no` parameter with this command to reset this configuration.

Command Syntax

```
show mpls mapped-routes
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls mapped-routes

Mapped-route          IPv4 FEC              MPLS-TP Tunnel
14.1.2.3/32           N/A                   NH4
```

Table 13 explains the show command output fields.

Table 13: show mpls mapped-routes output field

Field	Description
Mapped-route	Map the route of the interface.
IPv4	IPv4 address of the neighbor interface.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
MPLS-TP Tunnel	MPLS-TP tunnel can be provisioned between two arbitrary nodes in an MPLS-TP enabled network.

show mpls out-segment-table

Use this command to display detailed information of out-segment entries (also known as NHLFE) table.

Command Syntax

```
show mpls out-segment-table
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls out-segment-table
       Out-segment with ix: 1, owner: RSVP, out intf: eth1, out label: 52480
        Nexthop addr: 20.30.0.3        cross connect ix: 1, op code: Swap
        TX bytes:0, pkts:0, error pkts:0, discard pkts:0

       Out-segment with ix: 2, owner: RSVP, out intf: eth2, out label: 52481
        Nexthop addr: 30.30.0.3        cross connect ix: 1, op code: Swap
        TX bytes:0, pkts:0, error pkts:0, discard pkts:0Zx
```

Table 14 explains the show command output fields.

Table 14: show mpls out-segment-table output field

Field	Description
Out-segment ix	Displays the outbound segment index.
Out-Label	Label received from downstream neighbor for route.
Out-Intf	Short name of the physical interface through which traffic goes to the protected link.
Nexthop addr	Displays the IP address of the next hop.
Cross-connect ix	Displays the table index for the cross-connect.
Op code	PUSH = Replace the top label with another and then push one or more additional labels onto the label stack. SET = Set the next hop label.
Pkts	Number packet in the interface.
TX bytes	Size of the packets that transmitted to the neighbor.

Table 14: show mpls out-segment-table output field

Field	Description
Error pkts	Number of error packets.
Discard pkts	Number of packets discarded in the interface.

show mpls owner-rib-table

This command is modified to display backup information when LDP_LFA is enabled.

Command Syntax:

```
show mpls owner-rib-table
```

Parameters

None

Example

If LFA flag is disabled.

```
#show mpls owner-rib-table count
===============================================================
RIB INFO  Type : LDP
Session IP Address: 41.41.41.41  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
===============================================================
```

If LFA is enabled and Backup entries is not present.

```
#show mpls owner-rib-table count
===============================================================
RIB INFO  Type : LDP
Session IP Address: 41.41.41.41  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
Backup Info
Ftn Count 0, ILM Count 0 Dep ILM 0
===============================================================
```

If Backup entries are present.

```
#show mpls owner-rib-table count
===============================================================
RIB INFO  Type : LDP
Session IP Address: 41.41.41.41  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
Backup Info
Ftn Count 4, ILM Count 0 Dep ILM 0
===============================================================
===============================================================
RIB INFO  Type : LDP
Session IP Address: 17.17.17.17  Label Space: 0
Ftn Count 4, ILM Count 2 Dep ILM 2 VC 0
Backup Info
Ftn Count 4, ILM Count 0 Dep ILM 0
```

show mpls qos-resource

Use this command to display detailed QoS resource information.

Command Syntax

```
show mpls qos-resource IFNAME
```

Parameters

IFNAME	Display the interface name for a QoS resource

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls qos-resource eth1
<**********************************************>
              QOS RESERVED TABLE
<**********************************************>
HOLD PRIORITY : 0

HOLD PRIORITY : 1

HOLD PRIORITY : 2

HOLD PRIORITY : 3

HOLD PRIORITY : 4

HOLD PRIORITY : 5

HOLD PRIORITY : 6

HOLD PRIORITY : 7
<**********************************************>
   QOS AWAITING TABLE (static resources)
<**********************************************>
HOLD PRIORITY : 0

HOLD PRIORITY : 1

HOLD PRIORITY : 2

HOLD PRIORITY : 3

HOLD PRIORITY : 4

HOLD PRIORITY : 5

HOLD PRIORITY : 6
```

```
HOLD PRIORITY : 7
TSUP-173>
```

Table 15 explains the show command output fields.

Table 15: show mpls qos-resource output fields

Field	Description
QOS RESERVED TABLE	FTM/ILM entries for which QOS is reserved.
HOLD PRIORITY	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully
QOS AWAITING TABLE (static resources)	FTN/ILM entries for which QOS reservation is pending.

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show mpls vc-table

Use this command view configured virtual circuit (VC) components

Command Syntax

```
show mpls vc-table
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show mpls vc-table

VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label  Tunnel-Label
Nexthop Status
500    N/A        N/A          eth2          eth1          544        57
N/A    Active
#
```

Table 16 explains the show command output fields.

Table 16: show mpls vc-table output fields

Field	Description
VC-ID	The virtual circuit ID for the Provider Edge (PE) MPLS.
Vlan-ID	Virtual LAN (VLAN) ID number.
Inner-Vlan-ID	Inner Virtual LAN (VLAN) ID number.
Access-Intf	The Interface Access page provides a method with which to control access to specific areas of the interface.
Network-Intf	A networking interface allows a computer or mobile device to connect to a local area network (LAN) using Ethernet as the transmission mechanism.
Out Label	Label received from downstream neighbor for route.
Tunnel-Label	Used to provide reachability between PE devices.
Nexthop Status	Displays the network status of the next hop.

show mpls vrf

Use this command to display detailed information of all the configured VRF entries. Specify the name of the VRF to display information about a specific VRF entry.

Command Syntax

```
show mpls vrf-table
show mpls vrf-table VRFNAME (count|)
```

Parameters

`VRFNAME`	Display the MPLS VRF table by its configured name
`count`	Display the MPLS VRF FTN's count

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show mpls vrf new_vrf count
----------------------------------------------
Num VRF-FTNs         : 1          [UP: 1, INSTALLED: 1]
----------------------------------------------
----------------------------------------------
Num  VRF-FTNs         : 0          [UP: 0]
----------------------------------------------
```

Table 17 explains the show command output fields.

Table 17: show vrf-table output fields

Field	Description
Num VRF-FTNs	Number of FEC-to-NHLFE map counters in VRF protocol.
Num VRF-FTNs	Number of VRF FEC-to-NHLFE map counters in protocol.

show mpls vrf-forwarding-table vrf

This CLI can be used to display a tabular output of the VRF forwarding entries received from the remote PE via MPBGP.

Command Syntax

```
show mpls vrf-forwarding-table vrf <VRFNAME>
```

Parameters

VRFNAME	Display the MPLS VRF table by its configured name

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.1.

Examples

```
#show mpls vrf-forwarding-table vrf BEVrf
Owner    FEC                      FTN-ID    Oper-Status    Out-Label    Tunnel-id    NHLFE-id    Out-Intf    Nexthop
BGP      10.143.73.1/32            1         Up            24320        0            19          xe25        10.143.73.1
BGP      10.143.73.10/32           6         Up            25600        0            30          xe4         10.143.73.10
BGP      10.143.169.26/31          2         Up            24320        0            19          xe25        10.143.73.1
BGP      10.143.170.26/31          3         Up            24324        0            28          xe4         10.143.73.6
```

Table 18 explains the show command output fields.

Table 18: show mpls vrf-forwarding-table vrf output fileds

Field	Description
Owner	Displays the creator of this entry, typically a protocol such as BGP.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
FTN-ID	FEC-to-NHLFE identification.
Oper-Status	Displays the current status of the entry – Up or Down. It will be “UP” if the vrf entry is installed in the forwarder and it will be in “DOWN“ state if the vrf entry is not installed in the forwarder.
Out-Label	Displays the egress label for this FTN.
Tunnel-id	Tunnel identification to which packets of this FTN are going.
NHLFE-id	Next Hop Label Forwarding Entry identification (also known as out-segment entry identification).
Out-Intf	Name of the physical interface through which traffic goes.
Nexthop	Displays the IP address of the next hop.

show running-config interface mpls

Use this command to show the running system status and configuration for an MPLS interface.

Command Syntax

```
show running-config interface IFNAME mpls
```

Parameters

`IFNAME`	Display information for this interface name

Command Mode

Privileged Exec mode and Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show running-config interface eth1 mpls

#
```

show running-config mpls

Use this command to show any Multi-Protocol Label Switching (MPLS) related running configuration.

Command Syntax

```
show running-config mpls
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
>enable
#show running-config mpls
!
mpls propagate-ttl
!
!
!
#
```

show running-config service-template

Use this command to show service-template related running configuration.

Command Syntax

```
show running-config service-template
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#sho running-config service-template
!
service-template s2
 match outer-vlan 200
!
service-template s1
 match outer-vlan 100
!
service-template s3
 match outer-vlan 300
!
service-template s4
 match outer-vlan 400
!
```

show running-config vc

Use this command to show any Virtual Private Wire Service (VPWS) related running configuration.

Command Syntax

```
show running-config vc
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#show running-config vc
!
mpls l2-circuit vc1 1 2.2.2.2
!
mpls l2-circuit vc2 3 2.2.2.2
 tunnel-select-policy p1
!
!
interface xe2
 mpls-l2-circuit vc1 service-template s1 primary
 mpls-l2-circuit vc2 service-template s3 primary
!
```

show running-config vpls

Use this command to show any Virtual Private LAN Service (VPLS) related running configuration.

Command Syntax

```
show running-config vpls
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#show running-config vpls
!
mpls vpls vpls1 2
 signaling ldp
  vpls-type vlan
  vpls-peer 2.2.2.2
  exit-signaling
 exit-vpls
!
mpls vpls vpls2 4
 signaling ldp
  vpls-type vlan
  vpls-peer 2.2.2.2 tunnel-select-policy p1
  exit-signaling
 exit-vpls
!
!
interface xe2
 mpls-vpls vpls1 service-template s2
 mpls-vpls vpls2 service-template s4
 split-horizon group access1
!
```

show service-template

Use this command to display information of all or particular service templates.

Command Syntax

```
show service-template (detail|)
show service-template NAME
```

Parameters

detail	Show detailed information
NAME	Name of customer service template

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 1.3.3.

Examples

```
#show service-template detail
 Service-template : C2
  Services mapped : -
  Match criteria : 9/8

 Service-template : C1
  Services mapped : -
  Match criteria : 100

 Service-template : C3
  Services mapped : -
  Match criteria : 2-5

#show service-template C1
 Service-template : C1
  Services mapped : -
  Match criteria : 100
```

Table 19 explains the show command output fields.

Table 19: show service template output fields

Field	Description
Service-template	Creates a service template and enters service template configuration mode.
Services mapped	Used to match the type of services.
Match criteria	Used to approve the identification result or dismiss it.

show vccv statistics

Use this command to display VCCV messages received prior to advertising capability.

Command Syntax

```
show vccv statistics
```

Parameters

None

Command Mode

Privileged mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following is the sample output for `show vccv statistics` command.

```
#show vccv statistics
  CC Mismatch Discards - 10
```

Table 20 explains the show command output fields.

Table 20: show vccv statistics output fields

Field	Description
CC Mismatch Discards	Number of CC mismatch packets received from neighbor discarded.

srlg-disjoint

Use this command to set how to avoid the SRLGs (Shared Risk Link Groups) of a protected primary.

A fast-reroute/secondary path for an LSP that is disjoint from the primary ensures that a single point of failure on a particular link does not bring down both the primary and secondary paths in the LSP.

Note: The SRLG option configured in RSVP-TRUNK mode (see the secondary-priority srlg-disjoint command) takes higher preference than the option configured in RSVP router mode (this command).

Use the `no` form of this command to not avoid the SRLGs of a protected interface.

Command Syntax

```
srlg-disjoint (forced|preferred)
no srlg-disjoint
```

Parameters

`forced`	The router does not create the secondary/backup tunnel unless it avoids SRLGs of the primary-path/protected-interface.
`preferred`	With two explicit paths, the first explicit path tries to avoid the SRLGs of the primary-path/protected interface. If that does not work, the secondary/backup tunnel uses the second path (which ignores SRLGs).

Command Mode

Router RSVP mode

Example

```
#configure terminal
(config)#router rsvp
(config-rsvp)# srlg-disjoint forced
```

suppress-oper-log mpls l2vpn

Use this command to suppress the operator logs for the MPLS L2VPN service.

Use the `no` parameter with this command to display the operator logs for the MPLS L2VPN service.

Command Syntax

```
suppress-oper-log mpls l2vpn
no suppress-oper-log mpls l2vpn
```

Parameters

`l2vpn`	Operator logs of L2VPN.

Default

Disabled

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS#configure terminal
OcNOS(config)#suppress-oper-log mpls l2vpn
OcNOS(config)#commit
```

trace mpls

Use this command to trace the route traversed by a specified echo request packet in an MPLS protocol. Trace requests can be configured for LDP, RSVP, L2 VC, VPLS, Segment Routing and L3 VPN label switched paths.

```
trace mpls (6pe default X:X::X:X/M|ldp A.B.C.D/M|rsvp (tunnel-name NAME|egress
  A.B.C.D)|l3vpn VRFNAME A.B.C.D/M|ipv4 A.B.C.D/M) ({reply-mode
  (2)|flags|destination A.B.C.D|source A.B.C.D|timeout <1-500>|force-explicit-
  null|detail}|)
```

```
trace mpls (ospf-sr | isis-sr )(ipv4 A.B.C.D/M | sr-policy SR_POLICY_NAME
  candidate-path CANDIDATE_PATH_ID)({reply-mode (2|3)|flags | destination A.B.C.D
|source A.B.C.D | ttl <1-255> | timeout <1-500> | detail}|)
```

Parameters

6pe	FEC type is 6pe
default	VPN Instance Name (default)
X:X::X:X/M	6pe prefix address
ldp	FEC type is LDP
A.B.C.D/M	LDP prefix address
rsvp	FEC type is RSVP
tunnel-name	RSVP tunnel name
NAME	Tunnel name string
egress	RSVP tunnel egress
A.B.C.D	RSVP tunnel egress address
l3vpn	FEC type is MPLS VPN (L3-VPN)
VRFNAME	VPN instance name
A.B.C.D./M	VPN prefix
ipv4	FEC type generic; use for static/SNMP label switched paths
A.B.C.D/M	IPv4 prefix address
X:X::X:X/M	VPNv6 prefix
Ospf-sr	SR Protocol OSPF
Isis-sr	SR protocol ISIS
Ipv4	IPV4 FEC
A.B.C.D/M	Prefix with mask
Sr-policy	SR policy trace
SR_POLICY_NAME	SR policy name
Candidate-path	candidate path in sr policy
CANDIDATE_PATH_ID	candidate path id
reply-mode	Reply mode, one of
2	Reply via UDP/IP packet (default)
flags	Validate FEC stack

`destination`	Destination address
`A.B.C.D`	IPv4 address of the destination
`source`	Source address
`A.B.C.D`	IPv4 address of the source
`timeout`	Time to wait before rejecting the probe as a failure, in seconds
`<1-500>`	Timeout value
`force-explicit-null`	Force Explicit NULL label
`detail`	Print detailed output of the trace probe

Defaults

Default timeout value is 60 seconds.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3. The SR trace command was introduced in OcNOS version 4.1.

Examples

```
#trace mpls ipv4 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls l3vpn vrfa 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3
source 10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls ldp 10.10.0.0/24 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls rsvp egress 1.2.3.5 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

#trace mpls rsvp tunnel-name tun1 reply-mode 2 flags destination 127.1.2.3 source
10.10.0.1 timeout 65 detail force-explicit-null

     # trace mpls isis-sr ipv4 2.2.2.2/32 detail
# trace mpls ospf-sr ipv4 2.2.2.2/32 detail

# trace mpls isis-sr sr-policy aaa candidate-path 1
# trace mpls ospf-sr sr-policy ABC candidate-path 1
```

tunnel-id

Use this command to configure tunnel identifier for the MPLS transport tunnel to be used for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete tunnel identifier from the MPLS layer-2 virtual circuit.

Command Syntax:

```
tunnel-id <1-5000>
no tunnel-id
```

Parameters

`<1-5000>`	Identifying value for Tunnel-id

Default

By default, tunnel-id is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#tunnel-id 22
```

tunnel-name

Use this command to configure tunnel name for the MPLS transport tunnel to be used for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete tunnel name from the MPLS layer-2 virtual circuit.

Command Syntax:

```
tunnel-name NAME
no tunnel-name
```

Parameters

`NAME`	Identifying name for MPLS Tunnel

Default

By default, tunnel-name is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#tunnel-name pe1-to-pe2
```

tunnel-select-policy

Use this command to configure tunnel selection policy name for the MPLS transport tunnel to be used for the MPLS layer-2 virtual circuit.

Use the no parameter with this command to delete tunnel selection policy name from the MPLS layer-2 virtual circuit.

Command Syntax

```
tunnel-select-policy POLICYNAME
no tunnel-select-policy
```

Parameters

POLICYNAME	Selection policy name for MPLS Tunnel

Default

By default, tunnel-select-policy is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)#tunnel-select-policy policy1
```

vccv cc-type

Use this command to configure the VCCV control channel for MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable control channel from MPLS layer-2 virtual circuit.

Command Syntax

```
vccv cc-type (type-1|type-2|type-3)
no vccv cc-type (type-1|type-2|type-3)
```

Parameters

`type-1`	CC Type 1 - PWE3 Control Word with 0001b as first nibble
`type-2`	CC Type 2 - MPLS Router Alert Label
`type-3`	CC Type 3 - MPLS PW Label with TTL == 1

Default

By default, vccv is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)# vccv cc-type type-2
```

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vccv cv-type

Use this command to configure the VCCV control verification for MPLS layer-2 virtual circuit.

Use the no parameter with this command to disable control verification from MPLS layer-2 virtual circuit.

Command Syntax:

```
vccv cv-type (type-1|type-2|type-3|type-4)
no vccv cv-type (type-1|type-2|type-3|type-4)
```

Parameters

`type-1`	BFD IP/UDP-encapsulated for PW Fault Detection only
`type-2`	BFD IP/UDP-encapsulated for PW Fault Detection and AC/PW Fault Status Signalling
`type-3`	BFD PW-ACH-encapsulated for PW Fault Detection only
`type-4`	BFD PW-ACH-encapsulated for PW Fault Detection and AC/PW Fault Status Signalling

Default

By default, vccv is disabled

Command Mode

Configure Pseudowire mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls l2-circuit mycircuit 45678 1.2.3.4
(config-pseudowire)# vccv cv-type type-1
```

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CHAPTER 2
Differentiated Services Commands

This chapter describes the RSVP Differentiated Services (DiffServ) commands.

- map-route A.B.C.D
- override-diffserv
- primary class-to-exp-bit
- primary elsp-signaled
- primary llsp
- secondary map class
- secondary elsp-signaled
- secondary llsp
- show rsvp diffserv-info

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map-route A.B.C.D

Use this command to map a IPv4 prefix route onto a trunk. This route is to be used for packets that are mapped to a specific RSVP trunk.

Use the `no` parameter with this command for unmapping routes from specified trunks.

Note: Do not configure the local address as a map route, as explicit validation is not done. The wrong configuration may impact traffic.

Command Syntax

```
map-route A.B.C.D A.B.C.D
map-route A.B.C.D A.B.C.D CLASS
map-route A.B.C.D/M
map-route A.B.C.D/M CLASS
no map-route A.B.C.D A.B.C.D
no map-route A.B.C.D A.B.C.D CLASS
no map-route A.B.C.D/M
no map-route A.B.C.D/M CLASS
```

Parameters

`A.B.C.D`	Specify the IPV4 address to be mapped.
`A.B.C.D`	Specify a mask to be applied to the address being mapped.
`A.B.C.D/M`	Specify the IPV4 address to be mapped, with mask.
`CLASS`	Specify the DiffServ Class Name (for example, `be`, `ef` etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.

Default

By default, map route A.B.C.D is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 1.1.2.2/24 be
```

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override-diffserv

Use this command to enable the Differentiated Services (Diff-Serv) override configuration.

If a Path message is received without a Diff-Serv object by a Diff-Serv enabled node, it can be interpreted either as a request for an E-LSP (EXP-Inferred-PSC LSP) or as a request for Non-Diff-Serv LSP. This command supports the override option and when configured, the LSR interprets a path message without a Diff-Serv object as a request for Non-Diff-Serv LSP.

Use the `no` parameter with this command disable this feature.

Command Syntax

```
override-diffserv

no override-diffserv
```

Parameters

None

Default

By default, override diffserv is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router rsvp
(config-router)#override-diffserv
```

primary class-to-exp-bit

Use this command to configure a primary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the `no` parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
primary class-to-exp-bit CLASS <0-7>
no primary class-to-exp-bit CLASS <0-7>
```

Parameters

`CLASS`	Specify the DiffServ Class Name (for example, be, ef etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.
`<0-7>`	Exp bit which is to be mapped to this PHB.

Default

By default, primary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary class-to-exp-bit af12 3

(config)#rsvp-trunk T1
(config-trunk)#no primary class-to-exp-bit af12 3
```

primary elsp-signaled

Use this command to configure a primary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface.

The classes 1 to 7 are optional parameters that can be selected from node level PHB-EXP (Per-Hop Behavior) mapping as PHBs, which will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
primary elsp-signaled
primary elsp-signaled CLASS1
primary elsp-signaled CLASS1 CLASS2
primary elsp-signaled CLASS1  CLASS2 CLASS3
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4 CLASS5
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no primary elsp-signaled
```

Parameter

`CLASS<0-7>`	Diffserv class alias. e.g.: be, ef, af11, etc.

Default

By default, primary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary elsp-signaled cs2 cs5 cs6

(config)#rsvp-trunk T1
(config-trunk)#no primary elsp-signaled
```

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primary llsp

Use this command to configure a primary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
primary llsp CLASS
no primary llsp
```

Parameters

CLASS<0-7>	Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, primary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary llsp cs4

(config)#rsvp-trunk T1
(config-trunk)#no primary llsp
```

secondary map class

Use this command to configure a secondary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the no parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
secondary map class-to-exp-bit CLASS  <0-7>
no secondary map class-to-exp-bit CLASS  <0-7>
```

Parameters

CLASS	Diff-Serv class (queue) mapped to the particular PHB.
	Diffserv class alias e.g: be, ef, af11, etc.
<0-7>	Exp bit that is to be mapped to this PHB.

Default

By default, secondary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary class-to-exp-bit cs4 3

(config)#rsvp-trunk T1
(config-trunk)#no secondary class-to-exp-bit cs4 3
```

secondary elsp-signaled

Use this command to configure a secondary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface. The classes 1 to 7 are optional parameters can be selected from the node level PHB-EXP (Per-Hop Behavior) mapping as PHBs. They will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
secondary elsp-signaled
secondary elsp-signaled CLASS1
secondary elsp-signaled CLASS1 CLASS2
secondary elsp-signaled CLASS1 CLASS2 CLASS3
secondary elsp-signaled  CLASS1 CLASS2 CLASS3 CLASS4
secondary elsp-signaled  CLASS1 CLASS2 CLASS3 CLASS4 CLASS5
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no secondary elsp-signaled
```

Parameters

`CLASS<0-7>`	Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary elsp-signaled class cs3 cs6 cs2 cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary elsp-signaled
```

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secondary llsp

Use this command to configure a secondary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
secondary llsp CLASS
no secondary llsp
```

Parameters

`CLASS<0-7>`	Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary llsp class cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary llsp
```

show rsvp diffserv-info

Use this command to display node level Differentiated Services (Diff-Serv) configuration information. This information includes the node level PHB-EXP mapping configured for ELSP-signaled LSP.

Command Syntax

```
show rsvp diffserv-info
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following is a sample output of the `show rsvp diffserv-info` command.

```
#show rsvp diffserv-info
CLASS-EXP mapping:
CLASS    DSCP_value
 c5  101000 0
 be  000000 1
 cs1 001000 2
 cs3 011000 3
 cs2 010000 4
 cs4 100000 5
 cs6 110000 6
 cs7 111000 7
```

Table 2-1 explains the show command output fields.

Table 2-1: show rsvp diffserv-info output fields

Field	Description
CLASS	MPLS class type that corresponds to the DiffServ traffic engineering class.
EXP_value	Exp value is initialized at the ingress routing device only and overrides the rewrite configuration established for that forwarding class.

CHAPTER 3 Virtual Private LAN Service Commands

This chapter describes each VPLS (Virtual Private LAN Service) command.

- ac-admin-status
- ac-description
- clear mpls vpls
- control-word
- exit-signaling
- exit-if-vpls
- learning disable (VPLS Mode)
- learning disable (Interface VPLS Mode)
- learning enable
- no learning
- mpls vpls
- mpls-vpls service-template
- show mpls vpls
- show mpls vpls mac-address
- show mpls vpls split-horizon
- show mpls vpls statistics
- signaling ldp
- signaling bgp
- split-horizon (service-template)
- static-mac
- tunnel-select-policy
- ve-id
- vpls-ac-group
- vpls-description
- vpls fib-entry
- vpls-mtu
- vpls-peer
- vpls-peer manual
- vpls-type
- vpls-vc
- vpls-route-map

ac-admin-status

Use this command to configure the admin status of an attachment circuit specific to a VPLS instance.

Command Syntax

```
ac-admin-status down
no ac-admin-status
```

Parameter

`down`	set the admin role as DOWN

Default

By default, ac admin status is up

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows the configuration of admin status for attachment circuit specific to VPLS instance

```
#configure terminal
(config)#interface xe1
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#no ac-admin-status
```

ac-description

Use this command to add description for an attachment circuit specific for a VPLS instance

Use the no parameter with this command to remove the description

Command Syntax

```
ac-description LINE
```

Parameter

`LINE`	Characters describing this AC

Default

By default, ac description LINE is disabled

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows the configuration of description for attachment circuit specific to VPLS instance

```
#configure terminal
(config)#interface xe1
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#ac-description AC1_VPLS1
```

clear mpls vpls

Use this command to clear VPLS data.

Command Syntax

```
clear mpls vpls (NAME |) mac-addresses
```

Parameters

`NAME`	Clear data for the VPLS instance with name given
`mac-addresses`	Flush all MAC addresses for a VPLS instance

Command Mode

Exec mode and privileged exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear mpls vpls VPLS_123 mac-addresses
```

control-word

Use this command to enable control-word for a VPLS instance.

Use the `no` parameter with this command to disable control-word.

Command Syntax

```
control-word
no control-word
```

Parameters

None

Default

By default, control-word is disabled.

Command Mode

VPLS mode

Applicability

This command was introduced in OcNOS version 4.1.

Example

```
#(config-vpls)#control-word

#(config-vpls)#no control-word
```

exit-signaling

Use this command to exit the VPLS signaling configuration mode, and start signaling. To configure signaling with LDP, see the signaling ldp command. Other VPLS signaling configuration commands include show mpls vpls, show mpls vpls, vpls-vc, vpls-ac-group, and vpls-peer.

Note: It is *critical* to give this command after all VPLS signaling configurations are complete, otherwise signaling does not start.

Command Syntax

```
exit-signaling
```

Parameters

None

Default

No default value is specified

Command Mode

VPLS Signaling mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
# configure terminal
(config)#mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#exit-signaling
```

exit-if-vpls

Use this command to exit from Interface VPLS mode

Command Syntax

```
exit-if-vpls
```

Parameter

None

Default

No default value is specified

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows exiting from interface VPLS mode

```
#configure terminal
(config)#interface xe1
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#ac-description AC1_VPLS1
(config-if-vpls)#exit-if-vpls
(config-if-vpls)#exit
```

learning disable (VPLS Mode)

Use this command to disable learning for a VPLS instance.

Use the `no` form of this command to enable learning on a VPLS instance.

Note: This command disables learning on all the attachment circuits and pseudo-wires belonging to that VPLS instance.

Command Syntax

```
learning disable
no learning disable
```

Parameter

None

Default

By default, learning disable is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config-vpls)#mpls vpls vpls2 vlan 3
(config-vpls)#learning disable
(config-vpls)#exit

#configure terminal
(config-vpls)#mpls vpls vpls2 vlan 3
(config-vpls)#no learning disable
(config-vpls)#exit
```

learning disable (Interface VPLS Mode)

Use this command to disable learning on a particular Attachment Circuit (AC) interface.

Use the learning enable command to enable learning on a particular AC interface.

Note: This command disables MAC learning only on that interface.

Command Syntax

```
learning disable
```

Parameter

None

Default

By default, learning disable is disabled

Command Mode

Interface VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#learning disable
(config-if-vpls)#exit
```

learning enable

Use this command to enable learning on a particular attachment circuit (AC) interface.

Use the learning disable (Interface VPLS Mode) command to disable learning on a particular AC interface.

Note: This command enables MAC learning only on that AC interface.

Command Syntax

```
learning enable
```

Parameter

None

Default

By default, learning enable is enabled

Command Mode

Interface VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#learning enable
(config-if-vpls)#exit
```

no learning

Use this command to reset learning on a particular AC-interface to the global learning configuration.

Command Syntax

```
no learning
```

Parameter

None

Default

By default, no learning is disabled

Command Mode

Interface VPLS mode and VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#mpls-vpls vpls1 service-template st1
(config-if-vpls)#no learning
(config-if-vpls)#exit
(config)#

#configure terminal
(config)#mpls vpls vpls5 vlan 34
(config-vpls)#learning limit 500
(config-vpls)#exit
(config)#
```

mpls vpls

Use this command to create an instance of MPLS-based Virtual Private LAN Services (VPLS).

Use the `no` parameter with this command to delete an MPLS-based VPLS instance.

Note: OcNOS supports configuring the same Virtual Circuit Identifier (VC-ID) with different VPLS names for different LDP neighbors.

Command Syntax

```
mpls vpls NAME
mpls vpls NAME <1-4294967295>
no mpls vpls NAME
```

Parameters

NAME	VPLS instance identifier
<1-4294967295>	VPLS instance identifier

Default

By default, mpls vpls is disabled

Command Mode

Configuration mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls t1 6489
(config-vpls)#exit
```

mpls-vpls service-template

Use this command to bind a VPLS instance to a service template.

Use the no parameter with this command unbind the VPLS instance from service template.

Command Syntax

```
mpls-vpls VPLS_NAME service-template TEMPLATE_NAME
no mpls-vpls VPLS_NAME service-template TEMPLATE_NAME
```

Parameters

VPLS_NAME	VPLS instance name
TEMPLATE_NAME	Service template name

Default

N/A

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth1
(config-if)#switchport
(config-if)#mpls-vpls VPLS1 service-template C1
(config_if_vpls)#exit-if-vpls

(config-if)#no mpls-vpls VPLS1 service-template C1
(config_if)#exit-if-vpls
```

show mpls vpls

Use this command to display logging information configured for MPLS.

Command Syntax

```
show mpls vpls
show mpls vpls debug-detail
show mpls vpls detail
show mpls vpls mesh
show mpls vpls NAME
show mpls vpls NAME mesh
show mpls vpls NAME spoke
show mpls vpls spoke
show mpls vpls count
```

Parameters

`debug-detail`	Show detailed VPLS information for debugging purpose
`detail`	Display detailed VPLS information
`mesh`	Display MPLS VPLS Mesh Forwarding information. Use this parameter to display information about all core Virtual Circuit (VC) connections for all VPLS instances. Give the name of a VPLS instance to display information about that instance.
`NAME`	Display the identifying string for the VPLS domain
`spoke`	Display MPLS VPLS Spoke Forwarding information. Use this parameter to display information about all spoke VC connections for all VPLS instances. Give the name of a VPLS instance to display information about that instance.
`count`	Display the count of VPLS instances

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

Using `show mpls vpls` command without parameters displays information about all VPLS instances.

The example below displays information about the VPLS instance `v1`, returned when using the `NAME` parameter.

```
#show mpls vpls t1
Virtual Private LAN Service Instance: t1, ID: 1
 Group ID: 0, VPLS Type: Ethernet VPLS, Configured MTU: 0
 Description: none
 Configured interfaces: none
 Mesh Peers: 192.168.0.80 (Up)
             192.168.0.90 (Up)
 Spoke Peers: t100 (Up)
```

```
#
```

Table 3-2 explains the show command output fields.

Table 3-2: show mpls vpls t1 output field

Field	Description
Virtual Private LAN Service Instance	Number of VPLAN service instance.
ID	VPLAN identification detail for service instance.
Group ID	Group identification detail for VLAN.
VPLS Type	Type of VPLS in the interface.
Configured MTU	Number of configured MTU in the VPLs.
Description	Details of VPLS.
Configured interfaces	Description of the configured interfaces.
Mesh Peers	Configuring the VPLS mesh peers.
Spoke Peers	Configuring the VPLS spoke peers.

The example below displays the name of the VPLS instance, its ID, they type of instance (Ethernet), the M and S peers, and the signaling protocol. For the first entry, the signaling protocol is BGP and for the second entry it is LDP.

```
#show mpls vpls
Name   VPLS-ID      Type             MPeers     SPeers     SIG-Protocol
v1     100          Ethernet         1          0          BGP
v3     300          Ethernet         1          0          LDP
```

Table 3-3 explains the show command output fields.

Table 3-3: show mpls vpls output field

Field	Description
Name	Type of the MPLS protocol.
VPLS-ID	Identification detail of VPLS.
Type	Type of VPLS in MPLS protocol.
Mesh Peers	Configuring the VPLS mesh peers.
Spoke Peers	Configuring the VPLS spoke peers.
SIG-Protocol	Type of protocol in MPLS configuration.

The example below displays the output when using the debug-detail parameter. It displays information for VPLS instance `vpls1`, including the signaling protocol, create time, uptime, total down time, associated transport, traffic statistics if non-zero and statistics profile enabled, and so on.

```
#show mpls vpls debug-detail
Virtual Private LAN Service Instance: vpls1, ID: 300
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100

 Configured interfaces:
  Interface: xe4
   Status: Up
   Service-template : vpls1
   Match criteria : 440

Mesh Peers:
   2.2.2.2 State: Installed
     CreateTime: 08:56:53, UpTime: 08:56:53
     TotalDownTime: N/A, FlapCount: 0, LastFlapReason: N/A
     Tunnel-Id: 11
     Transport: owner CLI, ftn_ix 9
   3.3.3.3 State: Installed
     CreateTime: 08:56:53, UpTime: 08:56:53
     TotalDownTime: N/A, FlapCount: 0, LastFlapReason: N/A
     Tunnel-Name: t1
     Transport: owner RSVP, ftn_ix 8
   4.4.4.4 State: Installed
     CreateTime: 08:56:53, UpTime: 08:49:39
     TotalDownTime: 00:01:11, FlapCount: 1, LastFlapReason: FIB delete from
protocol
     Tunnel-Policy: p1
     Transport: owner SR_POLICY, ftn_ix 13
```

The example below displays the output when using the `detail` parameter. It displays information for VPLS instance `v1`, including the signaling protocol.

```
#show mpls vpls detail
Virtual Private LAN Service Instance: vpls2, ID: 2
 SIG-Protocol: LDP
  Route-Distinguisher :2:1
  Route-Target : both 2:30, export 10.10.0.2:29, import 2:28, both 2:27,
export 10.10.0.2:26, import 2:25, both 2:24, export 10.10.0.2:23, import 2:22,
                 both 2:21, export 10.10.0.2:20, import 2:19, both 2:18,
export 10.10.0.2:17, import 2:16, both 2:15, export 10.10.0.2:14, import 2:13,
                 both 2:12, export 10.10.0.2:11, import 2:10, both 2:9, export
10.10.0.2:8, import 2:7, both 2:6, export 10.10.0.2:5, import 2:4,
                 both 2:3, export 10.10.0.2:2, import 2:1
  L2 VPN ID :2:1
```

```
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 9000
Description: none
service-tpid: dot1.q
Operating mode: Tagged
Svlan Id: 0
Svlan Tpid: 8100
MAC Withdrawal:

Configured interfaces:
 Interface: xe29.2
  Status: Up
  Subinterface Match Criteria(s) :
  dot1q 2

Mesh Peers:
  150.1.1.1 (Type: Ethernet VLAN) (Negotiated - CW: No, FAT: No) (Up)
(UpTime: 00:11:57)
    FEC signaling element: FEC129
    FEC129 details:
      agi : 00 0A 00 02 00 00 00 01
      saii: 100.1.1.1
      taii: 150.1.1.1
```

Table 3-4 explains the show command output fields.

Table 3-4: show mpls vpls details output field

Field	Description
Virtual Private LAN Service Instance	Number of VPLS service instance.
ID	VPLS identification detail for service instance.
SIG-Protocol	Type of protocol in MPLS configuration.
Attachment-Circuit	Details of the attached circuit in interface.
Learning	State of the interface.
Group ID	Group identification detail for VLAN.
VPLS Type	Type of VPLS in MPLS protocol.
Configured MTU	Number of configured MTU in the VPLs.
Description	Details of VPLS.
Service-tpid	Service TP identifier configured for the VPLS PW.
Operating mode	Type of mode in the interface.
Svlan Id	Configures a specific virtual LAN (VLAN).

Table 3-4: show mpls vpls details output field

Field	Description
Svlan Tpid	Service vlan TP identifier for the VPLS PW.
Redundancy admin role	Creating a Backup Administrator Role.
Redundancy oper role	Operational Role of the VPLS instance.
Configured interfaces	Details of the configured interfaces.
Interface	Selects an interface to configure.
Oper-state	Displays the current status of the cross-connect segment – Up or Down.
Service-template	Used to configure advanced service-related option.
Match criteria	Identifies prefix characteristics (network, BGP path attribute, nexthop, and so on) for a specific sequence.
Mesh Peers	Configuring the VPLS mesh peers.
PW Status Local	Used to perform limited local configuration changes, monitor device status and utilization, and simple local troubleshooting.
Remote	PW status of Remote end.

The example below displays the output provided when using the `mesh` parameter without a specific VPLS name.

```
VPLS-ID  Peer Addr Tunnel-Label In-Label Network-Intf Out-Label Lkps/St PW-
INDEX    SIG-Protocol
100      2.2.2.2   N/A           52503    eth2           53258      0/Dn
2        BGP
300      2.2.2.2   N/A           none      N/A            none      0/Dn
1        LDP
```

Table 3-5 explains the show command output fields.

Table 3-5: show mpls vpls output field

Field	Description
VPLS-ID	Identification details of the VPLS.
Peer Addr	IP address of the peer device.
Tunnel-Label	Tunnel label used for the next segment.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-Label	Label received from downstream neighbor for route.
Network-Intf	Installed as a result of configuring an interface.
Lkps/St	Opcode and Status of the VPLS PW.

Table 3-5: show mpls vpls output field

Field	Description
PW-INDEX	Index of the VPLS entry in PW table.
SIG-Protocol	Signaling protocol used for VPLS labels advertisement.

The following is a sample output of the `show mpls vpls detail` command displaying detailed information about all configured VPLS instances.

```
#show mpls vpls detail
Virtual Private LAN Service Instance: vpls3100, ID: 3100
SIG-Protocol: BGP
Route-Distinguisher :65010:3100
Route-Target :65010:3100
VE-ID :31
Attachment-Circuit :UP
Learning: Enabled
Group ID: 0, Configured MTU: 9216
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
Interface: xe26
Service-template : vpls3100_3100_13100
Match criteria : 3100
Action type : Translate
Action value : 4075
Outgoing tpid : dot1.q

Mesh Peers:
2.2.2.2 (Up)
```

Table 3-6 explains the show command output fields.

Table 3-6: show mpls vpls details output field

Field	Description
Virtual Private LAN Service Instance	Number of VPLS service instance.
ID	VPLS identification detail for service instance.
SIG-Protocol	Type of protocol in MPLS configuration.
Attachment-Circuit	Details of the attached circuit in interface.
Learning	State of the interface.
Group ID	Group identification detail for VLAN.
VPLS Type	Type of VPLS in MPLS protocol.
Configured MTU	Number of configured MTU in the VPLs.

Table 3-6: show mpls vpls details output field

Field	Description
Description	Details of VPLS.
Service-tpid	Service TP identifier configured for the VPLS PW.
Operating mode	Type of mode in the interface.
Svlan Id	Configures a specific virtual LAN (VLAN).
Svlan Tpid	Service vlan TP identifier for the VPLS PW.
Redundancy admin role	Creating a Backup Administrator Role.
Redundancy oper role	Operational Role of the VPLS instance.
Configured interfaces	Details of the configured interfaces.
Interface	Selects an interface to configure.
Oper-state	Displays the current status of the cross-connect segment – Up or Down.
Service-template	Used to configure advanced service-related option.
Match criteria	Identifies prefix characteristics (network, BGP path attribute, nexthop, and so on) for a specific sequence.
Mesh Peers	Configuring the VPLS mesh peers.
PW Status Local	Used to perform limited local configuration changes, monitor device status and utilization, and simple local troubleshooting.
Remote	PW status of Remote end.

The following is a sample output of the `show mpls vpls mesh` command displaying information about all the core VC connections for all VPLS instances.

```
#show mpls vpls mesh
VPLS-ID    Peer Addr        In-Intf    In-Label   Out-Intf   Out-Label Lkps/St
PW-INDEX SIG-Protocol Status  Ecmp-Group
1           192.168.0.80     eth0       16         eth0       640        1/Up
1          BGP Active   N/A
1           192.168.0.90     eth1       18         eth1       642        1/Up
2          BGP Active   N/A
2           192.168.0.80     eth0       19         eth0       641        1/Up
1          BGP Active   N/A
2           192.168.0.90     eth1       17         eth1       643        1/Up
2          BGP Active   N/A
#
```

Table 3-7 explains the show command output fields.

Table 3-7: show mpls vpls mesh output field

Field	Description
VPLS-ID	Identification details of the VPLS.
Peer Addr	IP address of the peer device.
In-Intf	Installed as a result of configuring an interface.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-Label	Label received from downstream neighbor for route.
Network-Intf	Installed as a result of configuring an interface.
Lkps/St	Opcode and Status of the VPLS PW.
PW-INDEX	Psuedo wire index
SIG-Protocol	Signalling protocol
Status	Status of Psuedo wire
Ecmp-Group	Equal cost multi path group

The following is a sample output of the `show mpls vpls spoke` displaying the spoke VC connection to the VPLS instance.

```
#show mpls vpls spoke
VPLS-ID    Virtual Circuit In-Intf     In-Label    Out-Intf    Out-Label Lkps/St
1          t100             eth2        20          eth2        640          1/Up
#
```

Table 3-8 explains the show command output fields.

Table 3-8: show mpls vpls spoke output field

Field	Description
VPLS-ID	Identification details of the VPLS.
Virtual Circuit	Used in transportation of data over a packet switch computer network.
In-Intf	Installed as a result of configuring an interface.
In-label	Displays the ingress (incoming interface) label for this segment.
Out-Label	Label received from downstream neighbor for route.
Network-Intf	Installed as a result of configuring an interface.
Lkps/St	Opcode and Status of the VPLS PW.

The following is a sample output of show mpls vpls count displaying information about total, active and inactive vpls instances.

```
#show mpls vpls count
-------------------------------
Total VPLS instances    : 2
Active VPLS instances   : 2
Inactive VPLS instances : 0
-------------------------------
```

Table 3-9 explains the show command output fields.

Table 3-9: show mpls vpls count output field

Field	Description
Total VPLS instances	Number of total VPLS instance.
Active VPLS instances	Number of active VPLS instance.
Inactive VPLS instances	Number of inactive VPLS instance.

show mpls vpls mac-address

Use this command to display retrieved VPLS learning mac-addresses on MPLS enabled node.

Command Syntax

```
show mpls vpls mac-address (name NAME |) (interface IFNAME |) (peer A.B.C.D |)
  (count |)
```

Parameters

NAME	Specify the name of the vpls instance
count	Counts the number of MAC address learned
IFNAME	Specify the name of interface
A.B.C.D	Specify the peer address

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show mpls vpls mac-address
VPLS-ID     MAC address        Learned from    Peer address
1           08:00:27:85:28:8a   eth1             1.1.1.1
1           08:00:27:99:91:1d   eth3             -


#show mpls vpls mac-address count
Total no of MAC addresses learnt :2


#show mpls vpls mac-address name vpls1
MAC address        Learned from    Peer address
08:00:27:85:28:8a   eth1             1.1.1.1
08:00:27:99:91:1d   eth3             -



#show mpls vpls mac-address name vpls1 count
Total no of MAC addresses learnt :2


#show mpls vpls mac-address interface eth1
VPLS-ID     MAC address        Learned from    Peer address
1           08:00:27:85:28:8a   eth1             1.1.1.1


#show mpls vpls mac-address interface eth1 count
Total no of MAC addresses learnt :1
```

```
#show mpls vpls mac-address name vpls1 interface eth1
MAC address        Learned from    Peer address
08:00:27:85:28:8a   eth1              1.1.1.1


#show mpls vpls mac-address name vpls1 interface eth1 count
Total no of MAC addresses learnt :1


#show mpls vpls mac-address peer 1.1.1.1
VPLS-ID     MAC address        Learned from    Peer address
1           08:00:27:85:28:8a   eth1              1.1.1.1


#show mpls vpls mac-address peer 1.1.1.1 count
Total no of MAC addresses learnt :1


#show mpls vpls mac-address name vpls1 peer 1.1.1.1
MAC address        Learned from    Peer address
08:00:27:85:28:8a   eth1              1.1.1.1


#show mpls vpls mac-address name vpls1 peer 1.1.1.1 count
Total no of MAC addresses learnt :1


#show mpls vpls mac-address interface eth1 peer 1.1.1.1
VPLS-ID     MAC address        Learned from    Peer address
1           08:00:27:85:28:8a   eth1              1.1.1.1


# show mpls vpls mac-address interface eth1 peer 1.1.1.1 count
Total no of MAC addresses learnt :1


#show mpls vpls mac-address name vpls1 interface eth1 peer 1.1.1.1
MAC address        Learned from    Peer address
08:00:27:85:28:8a   eth1              1.1.1.1


#show mpls vpls mac-address name vpls1 interface eth1 peer 1.1.1.1 count
Total no of MAC addresses learnt :1
```

Table 3-10 explains the show command output fields.

Table 3-10: show mpls vpls mac-address output field

Field	Description
MAC address	Used to forward the packet into a given VPLS instance.
Learned from	MAC addresses learned from a specific interface.
Peer address	IP address of the peer device.

show mpls vpls split-horizon

Use this command to display the split horizon grouping information.

Command Syntax

```
show mpls vpls split-horizon <vpls_name>
```

Parameters

<vpls_name>	(Optional). Specifies the name of the VPLS.

Default

None

Command Mode

EXEC mode

Applicability

This command was introduced before OcNOS version 6.5.2.

Example

The following example shows a summary of all VPLS instances, showing their VPLS ID, type, details (such as spokes or ACs), associated interfaces, and the split horizon group they belong to:

```
#show mpls vpls split-horizon
+------------+------------+-----------------+---------------+--------------+
|   VPLSID   |   Type     |     Details     |   Interface   |     Group    |
+------------+------------+-----------------+---------------+--------------+
800           AC          st2                xe9             access2
800           AC          -                  xe17.800        access1
800           Spoke       vc2                -               network
2000          Spoke       vc1                -               access1
```

The following example shows the split horizon details for a specific VPLS instance, showing similar information but focused on the specified VPLS ID:

```
#show mpls vpls split-horizon vpls800
+------------+------------+-----------------+---------------+--------------+
|   VPLSID   |   Type     |     Details     |   Interface   |     Group    |
+------------+------------+-----------------+---------------+--------------+
800           AC          st2                xe9             access2
800           AC          -                  xe17.800        access1
800           Spoke       vc2                -               network
```

The following example shows when there is no VPLS is configured with the specified VPLS ID:

```
#show mpls vpls split-horizon vpls200
% No VPLS with name: vpls200 configured.
```

The following example shows VPLS split horizon details for VPLS ID 2000:

```
#show mpls vpls split-horizon vpls2000
+------------+------------+-----------------+---------------+--------------+
```

```
   |   VPLSID   |   Type     |      Details      |   Interface   |     Group     |
   +------------+------------+-----------------+---------------+--------------+
   2000           Spoke       vc1                 -               access1
```

Table 3-10 explains the show command output fields.

Table 3-11: show mpls vpls split-horizon output field

Field	Description
VPLSID	The ID of the VPLS instance. It uniquely identifies each VPLS in the network.
Type	The type of connection within the VPLS instance.
Details	Additional details about the VPLS connection type, such as the virtual circuit (VC) number or other identifiers related to the connection.
Interface	The physical or logical interface on the PE router that is part of the VPLS instance.
Group	The split-horizon group associated with the VPLS instance.

show mpls vpls statistics

Use this command to display MPLS traffic statistics for VPLS network or access or all ports.

Note: Multicast traffic statistics not supported by hardware.

Command Syntax

```
show mpls vpls NAME statistics

show mpls vpls NAME statistics ((network-port ((peer A.B.C.D)|(spoke-vc VC-NAME)|))
  | (access-port (IFNAME (ethernet|(vlan <1-4094>))|)))
```

Parameters

NAME	Name of the VPLS instance
a.b.c.d	Mesh peer address of VC instance
VC-NAME	Name of the spoke VC instance
IFNAME	Name of the access-port interface
<1-4094>	VLAN ID of access-port of type VLAN

Command Mode

Exec mode and privileged exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls vpls v1 statistics
Virtual Private LAN Service Instance: v1, ID: 10

 Access port statistics:
 Interface: xe3/4 VLAN ID: 2
   RX:  Input packets  : 10
        Input bytes    : 640
   TX:  Output packets : 0
        Output bytes   : 0

 Network port statistics:
 Mesh Peer: 8.8.8.8 (Up)
   RX:  Input packets  : 0
        Input bytes    : 0
   TX:  Output packets : 10
        Output bytes   : 640
```

Table 3-10 explains the show command output fields.

Table 3-12: show mpls vpls statistics output field

Field	Description
Access port statistics	Traffic statistics on Access port of VC/VPLS.
Network port statistics	Traffic statistics on Provider port of VC/VPLS.
Interface	Type of interface in the network.
VLAN ID	Identification details of the VPLS.
Mesh Peer	Configuring the VPLS mesh peers.
RX	Number of received packets.
Input packets	Number of hello packets received from the neighbor.
Input bytes	Size of hello packets received from the neighbor.
TX	Number of packets transmitted.
Output packets	Number of hello packets sent to the neighbor.
Output bytes	Size of hello packets sent to the neighbor.

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signaling ldp

Use this command to establish a pseudowire connection between Provider Edge (PE) routers. Use this command to use the Label Distribution Protocol (LDP) for signaling and to support VPLS auto-discovery between VPLS instances.Using this command triggers LDP to signal a pseudowire between the configured VPLS peers in the same VPLS instance. The `vpls-peer` command is used to identify the VPLS peers that are part of a VPLS instance

Note: Issuing this command puts the router into VPLS signaling (`config-vpls-sig`) mode.

Use the `no` parameter with this command to remove (tear down) pseudowires with other PE routers.

Command Syntax

```
signaling ldp
no signaling ldp
```

Parameters

None

Default

By default, signaling ldp is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#vpls-peer 97.97.97.97
(config-vpls-sig)#exit
```

signaling bgp

Use this command to establish a pseudowire connection between Provider Edge (PE) routers. Use this command to use the Border Gateway Protocol (BGP) for signaling and to support VPLS auto-discovery between VPLS instances.Using this command triggers BGP to auto-discover VPLS peers and signal pseudowire between the VPLS peers in the same VPLS instance.

Note: Issuing this command puts the router into VPLS signaling .

Use the `no` parameter with this command to remove (tear down) pseudowires with other PE routers.

Command Syntax

```
signaling bgp
no signaling bgp
```

Parameters

None

Default

By default, signaling bgp is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling bgp
(config-vpls-sig)#exit
```

signaling bgp

Use this command to establish a pseudowire connection between Provider Edge (PE) routers. Use this command to use the Border Gateway Protocol (BGP) for signaling and to support VPLS auto-discovery between VPLS instances.Using this command triggers BGP to auto-discover VPLS peers and signal pseudowire between the VPLS peers in the same VPLS instance.

Note: Issuing this command puts the router into VPLS signaling .

Use the `no` parameter with this command to remove (tear down) pseudowires with other PE routers.

Command Syntax

```
signaling bgp
no signaling bgp
```

Parameters

None

Default

By default, signaling bgp is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling bgp
(config-vpls-sig)#exit
```

split-horizon (service-template)

Use this command to configure split-horizon group for vpls attachment circuit.

Use the `no` form of this command to remove split-horizon group from vpls attachment circuit.

Command Syntax

```
split-horizon group (network | access1 | access2)
no split-horizon group
```

Parameters

`network`	Split-horizon group name network
`access1`	Split-horizon group name access1
`access2`	Split-horizon group name access2

Default

By default, split horizon is disabled.

Command Mode

Interface VPLS mode

Applicability

This command was introduced before OcNOS version 6.3.0 and applicable only on Qumran1 devices.

Examples

```
#configure terminal
(config)#interface xe1
(config-if)#switchport
(config-if)#mpls-vpls vpls1 service-template vc1
(config-if-vpls)#split-horizon group access1
(config-if-vpls)#no split-horizon group
```

static-mac

Use this command to add static MAC address to attachment circuit specific for a VPLS instance.

Use the `no` parameter with this command to remove static MAC address.

Note: It is not supported, if the user configures same mac address on different attachment circuits for same VPLS instance.

Command Syntax

```
static-mac XXXX.XXXX.XXXX
no static-mac XXXX.XXXX.XXXX
```

Parameter

`XXXX.XXXX.XXXX` MAC address in HHHH.HHHH.HHHH format.

Default

By default, mac is disabled

Command Mode

Interface VPLS

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
(config)#interface ce11/2
(config-if)#mpls-vpls vpls2 service-template vc1
(config-if-vpls)#static-mac 0000.0400.0602
```

tunnel-select-policy

Use this command to set tunnel-policy for a VPLS instance. This command is used for BGP signaling based VPLS instance. This will be used while selecting transport for the peer.

Use the `no` parameter with this command to un-configure tunnel selection policy.

Command Syntax

```
tunnel-select-policy TNLPOLICYNAME
no tunnel-select-policy
```

Parameters

TNLPOLICYNAME	Name of tunnel policy

Command Mode

VPLS SIG mode

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
#configure terminal
(config)#mpls vpls vpls1 10
(config-vpls)#signaling bgp
(config-vpls-sig)#tunnel-select-policy policy1
```

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ve-id

Use this command to configure a VPLS Edge (VE) device. Each Provider Edge (PE) device participating in a VPLS must have at least one VE ID. When the PE is connected to several u-PEs (Layer 2 PE devices used to provide Layer 2 aggregation), there are unique VE ID's for each u-PE. The PE may also be assigned a VE ID, if it is to act as the VE for the VPLS.

Use the `no` parameter with this command to remove a VE ID.

Command Syntax

```
ve-id <1-65535>
no ve-id <1-65535>
```

Parameters

`<1-65535>`	VE-ID's range is between 1 and 65535. This should be unique among the VPLS Peers for a VPLS instance.

Default

By default, ve id is disabled

Command Mode

BGP VPLS Signaling mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 100
(config-vpls)#signaling bgp
(config-vpls-sig)#ve-id 2
(config-vpls-sig)#exit
```

vpls-ac-group

Use this command to assign an Attachment Circuit (AC) group to VPLS.

Use the `no` parameter with this command to remove an AC group.

Command Syntax

```
vpls-ac-group GROUPNAME
no vpls-ac-group
```

Parameter

GROUPNAME	Enter a name for the AC group

Default

By default, vpls ac group is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 12
(config-vpls)#vpls-ac-group new-ac
(config-vpls)#no vpls-ac-group
```

vpls-description

Use this command to add a description line for a VPLS instance.

Use the `no` parameter with this command to remove a VPLS description.

Command Syntax

```
vpls-description LINE
no vpls-description (LINE|)
```

Parameter

LINE	Enter a text string for the VPLS instance

Default

By default, vpls description is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls test 34
(config-vpls)#vpls-description This is for testing
(config-vpls)#exit
```

vpls fib-entry

Use this command to create a static VPLS FIB entry. When a VPLS peer is configured manually, no signaling is done. Therefore, a VPLS static entry must be created for all manually created nodes.

Use the `no` option with this command to delete a static VPLS FIB entry.

Command Syntax

```
vpls fib-entry VPLS-ID (peer A.B.C.D| spoke-vc VC-NAME) IN-LABEL OUT-INTF OUT-LABEL
no vpls fib-entry VPLS-ID ((peer A.B.C.D)| (spoke-vc VC-NAME))
no vpls fib-entry VPLS-ID ((peer A.B.C.D)| (spoke-vc VC-NAME)) IN-LABEL OUT-INTF
  OUT-LABEL
```

Parameters

`VPLS-ID`	VPLS identifier
`peer`	Mesh peer address VPLS identifier
A.`B.C.D`	Peer IPv4 Address.
`spook-vc`	Spoke VC
`VC-NAME`	Virtual Circuit name
`IN-LABEL`	Incoming label value in the range of <16-15999>
`OUT-INTF`	Provider-facing interface
`OUT-LABEL`	Outgoing label value in the range of <16-15999>

Default

By default, vpls fib entry is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The first example shows how to configure VPLS FIB entry 100 with mesh peer 97.97.97.97 for incoming label 15999, outgoing interface eth2 with outgoing label 15999:

```
#configure terminal
(config)#vpls fib-entry 100 peer 97.97.97.97 15999 eth2 15999
```

The second example shows how to configure VPLS FIB entry 100 with spoke-vc t1 for incoming label 15999, outgoing interface eth2 with outgoing label 15999:

```
#configure terminal
(config)#vpls fib-entry 100 spoke-vc t1 15999 eth2 15999
```

vpls-mtu

Use this command to set the Maximum Transmission Unit (MTU) size for a given VPLS instance. This size is signaled to peer VPLS routers.

Use the `no` parameter with this command to remove the MTU size setting.

Command Syntax

```
vpls-mtu <576-65535>
no vpls-mtu (<576-65535>|)
```

Parameter

`<576-65535>`	Range of MTU size allowed for a VPLS instance

Default

By default, vpls mtu is 1500

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls test 34
(config-vpls)#vpls-mtu 6506
(config-vpls)#exit
```

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vpls-peer

Use this command to add a peer to a VPLS domain. This command triggers Label Distribution Protocol (LDP) signaling by default.

Use the `no` parameter to delete a VPLS virtual circuit for a specific peer.

Use the `no` parameter to delete a VPLS tunnel mapping for a specific peer to delete/unmap tunnel-id, tunnel-name or tunnel-select-policy for a vpls-peer.

Command Syntax

```
vpls-peer A.B.C.D ((agi NAME saii NAME taii NAME) |) ((tunnel-id <1-5000>) |
  (tunnel-name TNLNAME) |) ((tunnel-select-policy TNLPOLICYNAME)|)
```

```
no vpls-peer A.B.C.D ((tunnel-id | tunnel-name | tunnel-select-policy) |)
```

Parameters

`A.B.C.D`	The address of a VPLS peer node to which a mesh virtual circuit is to be created
`tunnel-id`	Static Tunnel Identifier
`<1-5000>`	Identifying value for Tunnel-id
`A.B.C.D`	IPv4 Address for end-point for FEC129 MPLS Layer-2 Virtual Circuit
`agi`	Specify the value used for the AGI in FEC129 MPLS Layer-2 Virtual Circuit
`NAME`	AGI value for FEC129 MPLS Layer-2 Virtual Circuit
`saii`	Specify the value used for the SAII in FEC129 MPLS Layer-2 Virtual Circuit
`NAME`	SAII value for FEC129 MPLS Layer-2 Virtual Circuit
`taii`	Specify the value used for the TAII in FEC129 MPLS Layer-2 Virtual Circuit
`NAME`	TAII value for FEC129 MPLS Layer-2 Virtual Circuit
`tunnel-name`	Tunnel name of the MPLS LSP (or Layer 2 Tunnel) to be used
`TUNNELNAME`	Identifying name for Tunnel
`tunnel-select-policy`	Tunnel selection policy
`TNLPOLICYNAME`	Name of tunnel policy

Default

By default, vpls peer is disabled

Command Mode

VPLS Signaling mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#vpls-peer 97.97.97.97
```

```
(config-vpls-sig)#vpls-peer 97.97.97.97 tunnel-id 24
(config-vpls)#exit
(config)#exit
```

vpls-peer manual

Use this command to statically configure a VPLS peer. Because this command is not used in signaling mode, no signaling is used to set up the virtual circuit. At least one such peer configuration is required for every VPLS instance.

Use the `no` parameter with this command to remove a statically configured VPLS peer.

Use the `no` parameter to delete a VPLS tunnel mapping for a specific peer to delete/unmap tunnel-id, tunnel-name or tunnel-select-policy for a vpls-peer.

Command Syntax

```
vpls-peer A.B.C.D ((tunnel-id <1-5000>) | (tunnel-name TNLNAME) |) (manual|)
no vpls-peer A.B.C.D ((tunnel-id | tunnel-name | tunnel-select-policy) |)
```

Parameters

`A.B.C.D`	The address of a VPLS peer node to which a mesh virtual circuit is to be created
`tunnel-id`	Static Tunnel Identifier
`<1-5000>`	Identifying value for Tunnel-id
`tunnel-name`	Tunnel name of the MPLS LSP (or Layer 2 Tunnel) to be used
`TUNNELNAME`	Identifying name for Tunnel

Default

By default, vpls peer A.B.C.D manual is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 100
(config-vpls)#vpls-peer 97.97.97.97 manual
(config-vpls)#vpls-peer 97.97.97.97 tunnel-id 24 manual
(config-vpls)#exit
(config)#exit
```

vpls-type

Use this command to assign a type (either Ethernet or VLAN) for VPLS.

Note: The default type is chosen as Ethernet.

Command Syntax

```
vpls-type (ethernet|vlan)
```

Parameter

ethernet	Designate Ethernet as the VPLS type
vlan	Designate VLAN as the VPLS type

Default

By default, vpls type is ethernet

Command Mode

signaling ldp mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#vpls-type vlan
(config-vpls-sig)#vpls-peer 2.2.2.2
(config-vpls-sig)#exit
(config-vpls)#exit
```

vpls-vc

Use this command add a spoke virtual circuit to VPLS domain.

Use the `no` parameter to remove this configuration.

Command Syntax

```
vpls-vc NAME (ethernet|vlan|)
vpls-vc NAME (secondary NAME|) (ethernet|vlan|)
no vpls-vc NAME
```

Parameter

`NAME`	Enter a string that identifies the MPLS VC to add to the VPLS domain
`secondary`	Set the secondary spoke name
`NAME`	Enter a string that identifies the secondary spoke
`ethernet`	Identify the spoke type as Ethernet (default)
`vlan`	Identify the spoke type as VLAN.
`TNLNAME`	Specify the MPLS-TP tunnel-name.

Default

By default, vpls vc name is disabled

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#mpls vpls test 34
(config-vpls)#vpls-vc VC1
(config-vpls)#exit
(config)#exit
```

vpls-route-map

Use this command to configure the route-map name on an vpls instance.

Use the `no` parameter to remove the route-map configured.

Note: This command imports the extended-community color value configured on the route-map.

This command is used for BGP signaling based VPLS instance and not applicable for LDP signaling.

Command Syntax

```
vpls-route-map WORD
no vpls-route-map
```

Parameter

`WORD`	Name of the route-map.

Default

None

Command Mode

VPLS mode

Applicability

This command was introduced before OcNOS version 6.6.

Example

```
OcNOS(config)#mpls vpls a 1
OcNOS(config-vpls)#vpls-route-map map1
OcNOS(config-vpls)#exit
OcNOS(config)#

OcNOS(config)#mpls vpls a 1
OcNOS(config-vpls)#no vpls-route-map
OcNOS(config-vpls)#
```

CHAPTER 4 EVPN MPLS Commands

This chapter describes the EVPN MPLS commands:

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access-if-evpn

Use this command to create the evpn mpls access-port.

Use the no form of this command to delete the evpn mpls access-port.

Command Syntax

```
access-if-evpn
no access-if-evpn
```

Parameters

None

Command Mode

L2 Sub-interface mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#end
```

arp-cache disable

Use this command to disable the ARP cache for MAC/IP.

When the ARP cache is disabled on a access circuit, It does not reply to any ARP arriving on this port from the cache. It withdraws all MAC/IPs configured/learned on this access circuit and removes the MAC/IP entry for this AC from the local ARP cache.

It also makes sure that on withdrawing the MAC/IP route, the MAC does not become unknown. If all routes for this MAC are being withdrawn because of this command, then It advertises a MAC-only route. This is done so that the MAC does not become unknown and only the cache functionality becomes disabled.

Use the `no` form of this command to enable ARP cache for MAC/IP.

Note: On enabling the cache, an IP will be in conflict, then the cache enable will fail. The conflict has to be manually removed and then the cache enabled.

Note: When encapsulation default is configured under L2 subifp , then arp-packets will not be uplifted.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Command Syntax

```
arp-cache disable
no arp-cache disable
```

Parameters

None

Default

By default, the arp-cache option is enabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#arp-cache disable
(config-access-if)#end
```

arp-nd cos

Use this command to explicitly set or override the COS value (0-7) in the ARP/ND reply sent (also used in ARP/ND proxy sub-feature). By default ARP/ND reply will use CoS value of received ARP/ND request.

Use the no form of this command to use the default COS value.

Command Syntax

```
arp-nd cos <0-7>
no arp-nd cos
```

Parameters

<0-7>

Default

CoS 0 or previous ARP/ND reply CoS being used.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#arp-nd cos 5
(config-access-if)#end
```

arp-nd flood-suppress

Use this command to completely restrict the flood of ARP/ND packets towards remote PEs or other Access Circuit

This command applies only when the ARP cache and ND cache are enabled. When the ARP cache is disabled, ARP flooding is not suppressed even if this command is given. When the ND cache is disabled, ND flooding is not disabled, even if this command is given.

Use the `no` form of this command to not restrict the flood of ARP/ND packets.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Command Syntax

```
arp-nd flood-suppress
no arp-nd flood-suppress
```

Parameters

None

Default

By default, the arp-nd flood-suppress option is disabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#arp-nd flood-suppress
(config-access-if)#end
```

arp-nd refresh timer

Use this command to configure aging out the arp-cache and nd-cache entries for given time multiplied by 3 in seconds.

Use the `no` form of this command to remove the configuration.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Note: After this timer interval, it sends out ARP to revalidate and 3 times of this would lead to removal of the dynamic entry.

Command Syntax

```
evpn mpls arp-nd refresh-timer <3-190>
no evpn mpls arp-nd refresh-timer
```

Parameters

<3-190>	Refresh timer value in seconds (age-out is refresh time * 3)

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#config mode
(config)#evpn mpls arp-nd refresh-timer 100
(config)#no evpn mpls arp-nd refresh-timer
```

clear evpn mpls counters

Note: Use this command to clear the counters of a network port.

Command Syntax

```
clear evpn mpls counters ((network (ingress|(egress dst <A.B.C.D>)))| vpn-id <1-
  16777215> (network (ingress|(egress dst <A.B.C.D>))))
```

Parameters

`<1-16777215>`	VPN identifier
`A.B.C.D`	Ipv4 address

Command Mode

Exec Mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
DUT2#clear evpn mpls counters network egress dst 105.1.1.1
DUT2#
DUT2#clear evpn mpls counters vpn-id 10 network ingress
DUT2#
```

clear mac address-table

Use this command to clear dynamically learned MACs.

Note: To make evpn mpls disable and enable effective, system reboot is required.

Command Syntax

```
clear mac address-table dynamic evpn-mpls
clear mac address-table dynamic evpn-mpls evid <1-16777215>
clear mac address-table dynamic evpn-mpls evid <1-16777215> (address MACADDR|)
```

Parameters

`address`	Clear the specified MAC Address
`evid`	EVPN-MPLS tenant identifier
`<1-16777215>`	Range supported for EVID

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
#clear mac address-table dynamic evpn-mpls
#clear mac address-table dynamic evpn-mpls evid 30
OcNOS#clear mac address-table dynamic evpn-mpls evid 30 address 0000.0022.2222
```

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dynamic-learning disable

Use this command to disable dynamic learning of MACs at the Access Circuit.

This command also disables dynamic learning of MAC/IP from ARP/ND messages received on this Access Circuit.

Use the `no` form of this command to enable dynamic learning of MACs at the Access Circuit.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Note: IPv4 and IPv6 addresses associated with dynamic MACs also get cleaned with this command.

Command Syntax

```
dynamic-learning disable
no dynamic-learning disable
```

Parameters

None

Default

By default, the dynamic-learning option is enabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#dynamic-learning disable
(config-access-if)#end
```

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evi-name

Use this command to name the EVPN MPLS ID.

Use the `no` form of this command to remove the name of the EVPN MPLS ID.

Command Syntax

```
evi-name <WORD>
no evi-name
```

Parameters

WORD   EVI name. Maximum limit 10 characters (shall not be only numeric).

Default

None

Command Mode

EVPN MPLS mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#evpn mpls id 3
(config-evpn-mpls)#evi-name vni_ELAN
(config-evpn-mpls)#exit
```

evpn esi hold-time

Use this command to allow some time for the evpn mpls tunnels and xconnect tunnel to come at the time of evpn mpls initialization before making the ESI up. This avoids traffic to be black-holed when a new PE is added and connected to an already running CE for multi-homing.

Use the `no` form of this command to make the esi up immediately when configuring the `access-if` cli.

Command Syntax

```
evpn esi hold-time <10-300>
no evpn esi hold-time
```

Parameters

`<10-300>`	Hold time in seconds

Default

Default value is 0.

Command Mode

Configuration Mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)# evpn esi hold-time 100
(config)# exit
```

evpn irb

Use this command to map an IRB interface to an L2 VNID. This IRB interface can have multiple IP address as explained in IRB IP address CLI and can serve all subnets attached to the L2 VNID. Currently its 1:1 mapping between IRB interface & L2VNI.

This configuration enables default gateway behavior on that VTEP for that VNID and subnet and triggers default gateway MAC-IP route generation for the corresponding IRB IP with the local or global IRB MAC (router MAC) in distributed gateway in distributed gateway

This makes the default behavior as enable for gateway functionality.

No command disables default gateway behavior of the VTEP for that VNID subnet and triggers withdrawal of the default gateway MAC/IP advertisement done for that VNID subnet.

Use the `no` form this command to disable default gateway behavior of the VTEP for that VNID subnet and triggers withdrawal of the default gateway MAC/IP advertisement done for that VNID subnet.

Command Syntax

```
evpn irb [<NAME>|irb-advertise-host-route]
no evpn irb [<NAME>|irb-advertise-host-route]
```

Parameters

`NAME`	IRB interface name
`irb-advertise-host-route`	To advertise host IP prefixes

Command Mode

EVPN_MPLS_CONFIG Mode

Applicability

This command was introduced before OcNOS version 6.0.0.

irb-advertise-host-route introduced in OcNOS version 6.2.0.

Example

```
#config mode
(config)#evpn mpls id 10
(config-evpn-mpls)#evpn irb irb100

(config)#evpn mpls id 102
(config-evpn-mpls)#evpn irb-advertise-host-route
```

evpn irb-forwarding anycast-gateway-mac

Use this command to configure common anycast mac-address for all the IRB interfaces

Use the `no` form of this command to remove the global MAC address on all the IRB interfaces.

Command Syntax

```
evpn irb-forwarding anycast-gateway-mac MAC
no evpn irb-forwarding anycast-gateway-mac
```

Parameters

MAC	`XX-XX-XX-XX-XX-XX`	Source MAC address (Option 1)
	`XX:XX:XX:XX:XX:XX`	Source MAC address (Option 2)
	`XXXX.XXXX.XXXX`	Source MAC address (Option 3)

Command Mode

Configuration Mode

Applicability

This command was introduced before OcNOS version 4.1.

Example

```
#configure terminal
(config)#evpn irb-forwarding anycast-gateway-mac 0000.0000.1313
```

Or

```
(config)#evpn irb-forwarding anycast-gateway-mac 00:00:00:00:13:13
```

Or

```
(config)#evpn irb-forwarding anycast-gateway-mac 00-00-00-00-13-13

(config)#no evpn irb-forwarding anycast-gateway-mac
```

evpn irb-if-forwarding anycast-gateway-mac

Use this command to enable a Layer 3 interface to use the global anycast IRB MAC address.

Use the `no` form of this command to unconfigure the anycast MAC at a Layer 3 interface.

Command Syntax

```
evpn irb-if-forwarding anycast-gateway-mac
no evpn irb-if-forwarding anycast-gateway-mac
```

Parameters

None

Command Mode

IRB interface mode

L3 interface mode

Applicability

This command was introduced before OcNOS version 6.0.0.

L3 interface mode support was added in OcNOS version 6.1.0.

Example

```
#configure teminal
(config)#interface irb 1
(config-irb-if)#ip vrf forwarding vrfip
(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac
(config-irb-if)#no evpn irb-if-forwarding anycast-gateway-mac
(config)#interface xe1
(config-irb-if)#ip vrf forwarding vrfip
(config-irb-if)#evpn irb-if-forwarding anycast-gateway-mac
(config-irb-if)#no evpn irb-if-forwarding anycast-gateway-mac
```

evpn mpls enable

Use this command to enable evpn mpls functionality.

Use the no version of this command to disable evpn mpls functionality.

Note: To make evpn mpls disable and enable effective, system reboot is required.

Command Syntax

```
evpn mpls enable
no evpn mpls enable
```

Parameters

None

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
(config)#evpn mpls enable
(config)#no evpn mpls enable
```

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evpn mpls id

Use this command to set the VPN identifier to create an EVPN MPLS tunnel.

Note: To set the VPN identifier for an E-LAN, use the `evpn mpls id` command. For creating an E-LINE/XConnect, use the `evpn mpls xconnect` command with source and target identifiers.

Use the `no` parameter of this command to delete the EVPN MPLS ID for the MPLS tunnel.

Command Syntax

```
evpn mpls id <1-16777215> (| xconnect target-mpls-id <1-16777215>) (|control-word)
  (|etree-leaf)
no evpn mpls id <1-16777215>
```

Parameters

`evpn mpls id <1-16777215>`	Specifies the EVPN-MPLS tenant identifier. This is a numeric value ranging from 1 to 16777215.
`xconnect target-mpls-id <1-16777215>`	Enables E-LINE Xconnect. Specifies the target EVID for E-LINE Xconnect. This is a numeric value within the range from 1 to 16777215.
`control-word`	Enables control-word egress or ingress options for the given EVPN Instance (E-LAN or E-LINE). Requires the command hardware-profile filter evpn-mpls-cw to be enabled.
`etree-leaf`	(Optional) Configures the device as a leaf node within the E-Tree topology.

Command Mode

Configure mode

Applicability

Introduced in OcNOS version 3.0. Introduced `xconnect target-mpls-id <1-16777215>` parameter in the OcNOS version 4.0, `control-word` parameter in the OcNOS version 6.0.1, and `etree-leaf` parameter in the OcNOS version 6.5.1.

Example

```
(config)#evpn mpls id 10
(config-evpn-mpls)#exit

(config)#no evpn mpls id 10

(config)#evpn mpls id 100 xconnect target-mpls-id 200
(config-evpn-mpls)#exit

(config)#no evpn mpls id 100

(config)#evpn mpls id 300 xconnect target-mpls-id 400 control-word
(config-evpn-mpls)#exit

(config)#no evpn mpls id 300
```

Use the following command to configure the leaf node as an E-Tree leaf in a MPLS EVPN network.

```
(config)#evpn mpls id 10 etree-leaf
(config-evpn-mpls)#exit
```

evpn mpls irb

Use this command to enable EVPN-MPLS-IRB globally. Applicable to EVPN-MPLS

Use the `no` form this command to disable EVPN-MPLS.

Command Syntax

```
evpn mpls irb
no evpn mpls irb
```

Parameters

None

Command Mode

Configure Mode

Applicability

This command was introduced before OcNOS version 6.0.0.

Example

```
#config mode
(config)#evpn mpls irb
(config)#no evpn mpls irb
```

l3vni

Use this command to configure L3 Virtual Network Identifier for an ip vrf

Use the no form of this command to remove L3 Virtual Network Identifier

This identifies a tenant, with this one tenant can have L3VNI as its identifier and he can have multiple L2 networks identified with L2VNI's.

Note: L3 VNID cannot be same as L2 VNID.

Command Syntax

```
l3vni <L3 VNID>
no l3vni <L3 VNID>
```

Parameters

`<1-16777215>`	L3 VNID. Cannot be same as L2 VNID

Command Mode

Configure VRF mode

Applicability

This command was introduced in OcNOS version 4.1.

Example

```
#configure teminal
(config)#ip vrf vrfip
(config-vrf)#l3vni 10002
(config-vrf)#no l3vni 10002
```

mac

Use this command to configure a static MAC address with IPv4/IPv6 address or only MAC address under the Access-Circuit.

Use the no form of this command to unconfigure a static MAC address with IPv4/IPv6 address and only MAC address from the Access-Circuit.

Note: Not applicable for the AC port which is mapped with ELINE Service.

For static mac addresses,

1) the local static is given preference over remote learned static.

2) if same static mac is configured on more than one interface of same VPN then conflict state need to be resolved manually by removing that static-mac on all access-interfaces where it was configured.

Command Syntax

```
mac XXXX.XXXX.XXXX (| ip A.B.C.D | ipv6 X:X::X:X)
no mac XXXX.XXXX.XXXX (| ip A.B.C.D | ipv6 X:X::X:X)
```

Parameters

`XXXX.XXXX.XXXX`	Static mac address
`A.B.C.D`	Static IPv4 address
`X:X::X:X`	Static IPv6 address

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
#configure terminal
(config)# interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#mac 0000.0000.1001
(config-access-if)#mac 0000.0000.1002 ip 10.10.10.1
(config-access-if)#mac 0000.0000.1003 ipv6 1201::1
(config-access-if)#end
```

evpn mpls mac-ageing-time

Use this command to set the dynamically learned MAC aging time.

Use the `no` form of this command to set the age out the MACs in hardware to its default (300 seconds).

Note: This command affects the default bridge ageing time.

Command Syntax

```
evpn mpls mac-ageing-time <10-572>
no evpn mpls mac-ageing-time
```

Parameters

`<10-572>`	Ageing time in seconds.

Default

The default age out time is 300 seconds.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#evpn mpls mac-ageing-time 10
```

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evpn mpls multihoming enable

Use this command to enable evpn mpls multihoming

Use the `no` form of this command to disable evpn mpls multihoming.

Note: Node will have to be restarted for this to be applicable. If there are some nodes in topology which have multi-homed CEs, then the nodes which do not have multi-homed CEs should also enable multihoming, so that they can load share traffic to the multi-homed CEs.

Note: Before enabling multi-homing, configure the hardware-profiles with the hardware-profile filter evpn-mpls-mh commands.

Command Syntax

```
evpn mpls multihoming enable
no evpn mpls multihoming enable
```

Parameters

None

Default

By default evpn mpls multihoming is disabled.

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
#(config)# evpn mpls multihoming enable
#(config)# exit
```

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evpn mpls vtep-ip-global

Use this command to set the source IP address is used to establish BGP peering with neighbor MPLS Nodes and to establish the EVPN MPLS tunnels.

Use the no version of this command to delete the source IP address.

Command Syntax

```
evpn mpls vtep-ip-global A.B.C.D
no evpn mpls vtep-ip-global A.B.C.D
```

Parameters

A.B.C.D	IPv4 address type.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
(config)#evpn mpls vtep-ip-global 10.10.11.1
(config)#no evpn mpls vtep-ip-global 10.10.11.1
```

evpn multi-homed

Use this command to configure interfaces as multi-homed and configure esi-value in case of physical and static lag and system-mac in case of Dynamic lag.

The command `evpn multi-homed` allows users to configure single-active and port-active load-balancing Ethernet Segment Identifier (ESI) on a link with a multihomed Customer Edge (CE).

Use the `no` parameter of this command to unconfigure multi-homed on the interface.

Command Syntax

```
evpn multi-homed esi XX:XX:XX:XX:XX:XX:XX:XX:XX (load-balancing (single-active)|)

evpn multi-homed system-mac (XX-XX-XX-XX-XX-XX|XX:XX:XX:XX:XX:XX|XXXX.XXXX.XXXX)
  (load-balancing (port-active)|)

no evpn multi-homed (esi | system-mac)
```

Parameters

`XX:XX:XX:XX:XX:XX:XX:XX:XX`	ESI value in HH:HH:HH:HH:HH:HH:HH:HH:HH - 9 octet format
`XX-XX-XX-XX-XX-XX`	Host MAC address (Option 1)
`XX:XX:XX:XX:XX:XX`	Host MAC address (Option 2)
`XXXX.XXXX.XXXX`	Host MAC address (Option 3)
`port-active`	To support ESI configuration for port-active redundancy mode.
`single-active`	To support ESI configuration for single-active redundancy mode.

Default

Default value is 0.

Command Mode

Interface Mode

Applicability

This command was introduced in OcNOS version 4.0 and underwent modifications in the OcNOS version 6.4.1 and OcNOS version 6.4.2.

Example

```
#configure terminal
(config)#interface xe1
(config)#evpn multi-homed esi 00:11:22:33:44:55:66:77:88 load-balancing single-
active
(config)#exit

configure terminal
(config)#interface po1
(config)#evpn multi-homed system-mac 0000.0000.1111 load-balancing port-active
(config)#exit
```

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hardware-profile filter evpn-mpls-cw

This hardware filter needs to be enabled, to allow configuring EVPN-MPLS with control-word functionality per EVI. Filter cannot be disabled if "EVPN-MPLS" is globally enabled.

Before enabling EVPN MPLS per-evi control-word (evpn mpls id command), give this command.

Before disabling the hardware-profile, disable EVPN MPLS globally (no evpn mpls enable).

Note: You need to save the configuration and do a reboot after giving this command.

Use the disable form of this command to disable the configured hardware-profile.

Command Syntax

```
hardware-profile filter evpn-mpls-cw enable
hardware-profile filter evpn-mpls-cw disable
```

Parameters

None

Default

By default, EVPN MPLS control-word hardware-profile is disabled.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)# hardware-profile filter evpn-mpls-cw enable
(config)# hardware-profile filter evpn-mpls-cw disable
```

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hardware-profile filter evpn-mpls-mh

Use this command to enable the hardware-profile for EVPN MPLS multihoming to successfully activate multi-homing in the hardware.

Before enabling EVPN MPLS multihoming (evpn mpls multihoming enable command), give this command.

Before disabling the hardware-profile, disable EVPN MPLS multihoming.

Note: You need to save the configuration and do a reboot after giving this command.

Use the `disable` form of this command to disable the configured hardware-profile.

Command Syntax

```
hardware-profile filter evpn-mpls-mh enable
hardware-profile filter evpn-mpls-mh disable
```

Parameters

None

Default

By default, EVPN MPLS multihoming hardware-profile is disabled.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)# hardware-profile filter evpn-mpls-mh enable
(config)# hardware-profile filter evpn-mpls-mh disable
```

hardware-profile statistics evpn-mpls

Use this command to enable or disable filter statistics in hardware for evpn mpls network counters.

Note: You need to save the configuration and do a reboot after giving this command.

Command Syntax

```
hardware-profile statistics evpn-mpls enable
hardware-profile statistics evpn-mpls disable
```

Parameters

None

Default

By default, evpn mpls statistics profile is disabled.

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.2.

Example

```
#configure terminal
(config)# hardware-profile statistics evpn-mpls enable
(config)# hardware-profile statistics evpn-mpls disable
```

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host-reachability-protocol

Use this command to set the host reachable protocol to Ethernet-VPN over BGP. This defines BGP as the mechanism for host reachability advertisement to discover EVPN peers and to learn remote host details.

Use no form of this command to remove Ethernet-VPN as the host reachable protocol.

Command Syntax

```
host-reachability-protocol evpn-bgp WORD
no host-reachability-protocol evpn-bgp
```

Parameters

`WORD`	MAC Routing/Forwarding instance name. Maximum limit 32 characters

Default

None

Command Mode

EVPN MPLS Config mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
(config)#evpn mpls id 1
(config-evpn-mpls)#host-reachability-protocol evpn-bgp vrf1
```

evpn-route-map

Use this command to configure route-map on an evpn instance.

Use no form of this command to unconfigure route-map from an evpn instance.

Note: This command imports the extended-community color value configured on the route-map.

Command Syntax

```
evpn-route-map WORD
no evpn-route-map
```

Parameters

WORD	Name of the route-map.

Default

None

Command Mode

EVPN MPLS Config mode

Applicability

This command was introduced in OcNOS version 6.6.0.

Examples

```
OcNOS(config)#evpn mpls id 1
OcNOS(config-evpn-mpls)#evpn-route-map map1
OcNOS(config-evpn-mpls)#

OcNOS(config)#evpn mpls id 1
OcNOS(config-evpn-mpls)#no evpn-route-map
OcNOS(config-evpn-mpls)#s
```

ip address

Use this command to set anycast flag for primary and secondary subnets under IRB interface.

With this anycast gateway can be supported for multiple subnets.

Command Syntax

```
ip address [ <A.B.C.D/M>  | anycast]
ip address [ <A.B.C.D>  | <A.B.C.D> | anycast]
ip address [ <A.B.C.D/M>  | secondary | anycast]
ip address [ <A.B.C.D>  | <A.B.C.D> | secondary | anycast]
```

Default

The default value is router mac

Parameters

`anycast`	Anycast flag
`secondary`	Used for secondary address option

Command Mode

IRB_IF Mode

Applicability

The anycast flag was introduced in OcNOS version 6.3.0.

Example

```
(config)#interface irb2
(config-irb-if)#ip address 40.1.1.1/24 anycast
(config-irb-if)#ip address 41.1.1.1/24 secondary anycast
(config-irb-if)#
(config)#interface irb1
(config-irb-if)#ip address 42.1.1.1 255.255.255.0 anycast
(config-irb-if)#ip address 43.1.1.1 255.255.255.0 secondary anycast
(config-irb-if)#
```

ipv6 address

Use this command to set anycast flag for any configured subnets under IRB interface.

With this anycast gateway can be supported for multiple subnets.

Command Syntax

```
ipv6 address [ < X:X::X:X/M > | anycast]
```

Default

The default value is router mac

Parameters

anycast	Anycast flag

Command Mode

IRB_IF Mode

Applicability

The anycast flag was introduced in OcNOS version 6.3.0.

Example

```
(config)#interface irb1
(config-irb-if)# ipv6 address 1100::1/64 anycast
```

link-loss forwarding

Use this command to configure the link-loss forwarding on an access-interface.

Use the `no` parameter to un-configure the load interval globally.

Command Syntax

```
llf-enable
no llf-enable
```

Parameters

NA.

Default

NA.

Command Mode

Access-if mode

Applicability

This command was introduced in OcNOS version 6.6.0.

Example

```
#configure terminal
(config)#int xe22.2 sw
(config-if)#encapsulation dot1q 10
(config-if)#access-if-evpn
(config-acc-if-evpn)#llf-enable
```

mac-holdtime

Use this command to set the MAC hold time for a MAC/IP or MAC.

The feature holds the MAC in hardware until BGP has withdrawn from the neighbors. This helps to reduce the flooding to other access ports.

This setting applies when the L2 Subifp is shut down, the physical port on which the access port is down, or the access port is removed from the VNID using the no form of the map vnid command.

When the MAC hold time is configured as -1, then the MAC is not removed from the hardware and is also not withdrawn from EVPN BGP.

Use the `no` form of this command to remove the MAC hold time for the MAC/IP or MAC.

Note: When a MAC is moved to discard state, traffic to and from this MAC is discarded. This is applicable only on statically configured MAC/MAC-IPs.

Command Syntax

```
mac-holdtime <-1-300>
no mac-holdtime
```

Parameters

`<-1-300>`	MAC hold time in seconds. Specify -1 to "never expire".

Default

The default holdtime for mac is 3 seconds.

Command Mode

EVPN MPLS mode and ACC_IF mode

Note: When configured in both modes, then the ACC_IF mode value takes preference for that access port.

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#evpn mpls id 3
(config-evpn-mpls)#mac-holdtime -1
(config-evpn-mpls)#exit
```

mac-vrf

Use this command to create a MAC VRF to use in EVPN routes.

Use the `no` form of this command to delete the MAC VRF.

Command Syntax

```
mac vrf WORD
```

```
no mac vrf WORD
```

Parameters

`WORD MAC`	Routing/Forwarding instance name. Maximum limit 32 characters

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#mac vrf vrf1
(config)#no mac vrf vrf1
```

map vpn-id

Use this command to map a sub-interface to a tenant.

Use the no form of this command to remove the tenant.

Command Syntax

```
map vpn-id <1-16777215>
no map vpn-id <1-16777215>
```

Parameters

`<1-16777215>`	VNID

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#map vpn-id 1
(config-access-if)#end
```

nd-cache disable

Use this command to disable ND cache for MAC/IPv6.

When the ND cache is disabled on an Access Circuits, It does not reply to any ND arriving on this port from the cache. It withdraws all MAC/IPs configured/learned on this Access Circuit and removes the MAC/IP entry for this AC from the local ND cache.

It also makes sure that on withdrawing the MAC/IP route, the MAC does not become unknown. If all routes for this MAC are being withdrawn because of this command, then it advertises a MAC-only route. This is done so that the MAC does not become unknown and only the cache functionality becomes disabled.

Use the `no` form of this command to enable ND cache for MAC/IPv6.

Note: On enabling the cache, an IP will be in conflict, then the cache enable will fail. The conflict has to be manually removed and then the cache enabled.

Note: Not applicable for the AC port which is mapped with ELINE/Xconnect Service.

Command Syntax

```
nd-cache disable
no nd-cache disable
```

Parameters

None

Default

By default, the nd-cache option is enabled.

Command Mode

Access if evpn mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-evpn
(config-access-if)#nd-cache disable
(config-access-if)#end
```

show bgp l2vpn evpn

Use this command to display details about Layer 2 Virtual Private Network (L2VPN) Ethernet Virtual Private Network (EVPN) routes.

Note: A BGP EVPN route update received for an unreachable IP address is also listed by this command and as a best route. This is because the next hop tracking feature is not supported for the EVPN address family. However, the tunnel to this IP address is shown in unresolved state by the show nvo vxlan tunnel output.

Note: An E-tag (Ethernet tag) can have the value of zero/VID/VNID based on the use case. An E-tag can go up to 32 bits and no restrictions are noted in the RFC. Since an E-tag can have different values, it should not be compared with the label/VNID.

Command Syntax

```
show bgp l2vpn evpn ((vrf WORD)|(rd WORD)| time|)

show bgp l2vpn evpn mac-ip ((vrf WORD)|(rd WORD)|)

show bgp l2vpn evpn mcast

show bgp l2vpn evpn multihoming es-route <(rd WORD)|(vrf WORD)>

show bgp l2vpn evpn multihoming ethernet-ad-per-evi <(rd WORD)|(vrf WORD)>

show bgp l2vpn evpn multihoming ethernet-ad-per-es <(rd WORD)|(vrf WORD)>
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
MH-PE2#sh bgp l2vpn evpn
BGP table version is 22, local router ID is 102.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

[EVPN route type]:[ESI]:[VNID]:[relevent route informantion]
1 - Ethernet Auto-discovery Route
2 - MAC/IP Route
3 - Inclusive Multicast Route
4 - Ethernet Segment Route
5 - Prefix Route

    Network          Next Hop            Metric    LocPrf       Weight
Path  Peer          Encap

RD[101.1.1.1:1]
*>i  [1]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[18]
```

```
                       101.1.1.1           0         100           0        i
101.1.1.1       MPLS
*>i  [3]:[6001]:[32,101.1.1.1]
                       101.1.1.1           0         100           0        i
101.1.1.1       MPLS

RD[101.1.1.1:2]
*>i  [1]:[00:00:00:00:00:15:15:00:00:00]:[10]:[19]
                       101.1.1.1           0         100           0        i
101.1.1.1       MPLS

RD[101.1.1.1:22]
*>i  [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
                       101.1.1.1           0         100           0        i
101.1.1.1       MPLS
*>i  [4]:[00:00:00:00:00:15:15:00:00:00]:[32,101.1.1.1]
                       101.1.1.1           0         100           0        i
101.1.1.1       MPLS

RD[102.1.1.1:1] VRF[l2vrf1]:
*>   [1]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[19]
                       102.1.1.1           0         100           32768    i
----------      MPLS
* i                    101.1.1.1           0         100           0        i
101.1.1.1       MPLS
* i  [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
                       101.1.1.1           0         100           0        i
101.1.1.1       MPLS
*>   [2]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[48,0000:0000:aa11]:[0]:[19]
                       102.1.1.1           0         100           32768    i
----------      MPLS
*>
[2]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[48,0000:0000:aa12]:[32,12.12.12.10
]:[19]
                       102.1.1.1           0         100           32768    i
----------      MPLS
*>
[2]:[00:00:00:00:00:15:15:00:00:00]:[6001]:[48,0000:0000:aa13]:[128,1201::10]:
[19]
                       102.1.1.1           0         100           32768    i
----------      MPLS
* i  [3]:[6001]:[32,101.1.1.1]
                       101.1.1.1           0         100           0        i
101.1.1.1       MPLS
*>   [3]:[6001]:[32,102.1.1.1]
                       102.1.1.1           0         100           32768    i
----------      MPLS
* i  [3]:[6001]:[32,105.1.1.1]
                       105.1.1.1           0         100           0        i
105.1.1.1       MPLS

RD[102.1.1.1:2] VRF[l2vrf2]:
* i  [1]:[0]:[11]:[641]
                       105.1.1.1           0         100           0        i
105.1.1.1       MPLS
*>   [1]:[00:00:00:00:00:15:15:00:00:00]:[10]:[18]
                       102.1.1.1           0         100           32768    i
----------      MPLS
* i                    101.1.1.1           0         100           0        i
101.1.1.1       MPLS
```

```
* i  [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
                       101.1.1.1           0         100            0        i
101.1.1.1       MPLS

RD[102.1.1.1:22] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:00:00:15:15:00:00:00]:[4294967295]:[0]
                       102.1.1.1           0         100            32768    i
----------      MPLS
* i  [4]:[00:00:00:00:00:15:15:00:00:00]:[32,101.1.1.1]
                       101.1.1.1           0         100            0        i
101.1.1.1       MPLS
*>   [4]:[00:00:00:00:00:15:15:00:00:00]:[32,102.1.1.1]
                       102.1.1.1           0         100            32768    i
----------      MPLS

RD[105.1.1.1:1]
*>i  [3]:[6001]:[32,105.1.1.1]
                       105.1.1.1           0         100            0        i
105.1.1.1       MPLS

RD[105.1.1.1:2]
*>i  [1]:[0]:[11]:[641]
                       105.1.1.1           0         100            0        i
105.1.1.1       MPLS

Total number of prefixes 21
MH-PE2#
MH-PE2#
```

show evpn load-balance

Use this command to display ESI information in Single-Active or Port-Active mode. It assists the user in identifying whether the local device is in Active or Standby mode and understanding which election algorithm is used for ESI. In remote devices, information will only be displayed for ELINE services.

This command is used to debug and understand if the election process is occurring correctly. The commands on multi-homed devices are symmetric, and they provide insights into the election algorithm used for the DF election.

Command Syntax

```
show evpn load-balance (port-active | single-active | all)
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced before OcNOS version 6.4.1 and underwent modifications in the OcNOS version 6.4.2

Example

The following example displays ESI information using the `show evpn load-balance port-active and show evpn load-balance single-active` commands.

```
OcNOS#show evpn load-balance port-active
ESI                         AC-IF/PE     PE-IP-ADDRESS    Redundancy     Service-carving    weight   Revertive  AC-DF   Status
=======================================================================================================================
00:00:00:00:00:12:12:00:00:00  REMOTE    101.1.1.1        port-active      auto             0        NO         NA  ACTIVE
00:00:00:00:00:12:12:00:00:00  LOCAL     102.1.1.1       port-active      auto             0        NO          NA    STANDBY

#show evpn load-balance single-active
ESI                           AC-IF/PE  PE-IP-ADDRESS   Redundancy    Service-carving    weight   Revertive  AC-DF   Status
=======================================================================================================================
00:11:22:33:00:00:00:55:66:77  sa1.1     1.2.3.4       single-active   preference-based   200      NO          NO     ACTIVE
00:11:22:33:00:00:00:55:66:77  ----      3.4.5.6       single-active   preference-based   100      NO          NO     ----
```

Table 4-13 explains the output fields.

Table 4-13: show evpn load-balance port-active

Field	Description
ESI	Ethernet Segment Identifier, a unique identifier for an Ethernet Segment.
AC-IF/PE	This field indicates whether the ESI is associated with a local or remote Attachment Circuit (AC) or Provider Edge (PE).
PE-IP-ADDRESS	The IP address of the PE associated with the ESI.
Redundancy	Indicates whether the ESI is configured for port-active or single-active redundancy.
Service-carving	The service carving mode associated with the ESI.
weight	Weight assigned to the ESI.

Table 4-13: show evpn load-balance port-active

Field	Description
Revertive	Indicates whether the ESI is configured for revertive mode.
AC-DF	Attachment Circuit Designated Forwarder status.
Status	The status of the ESI, whether it's active or standby.

show evpn mpls

Use this command to display the EVPN Information.

Command Syntax

```
show evpn mpls (|id <1-16777215>)
```

Parameters

`<1-16777215>`	EVPN-MPLS tenant identifier

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
MH-PE2#sh evpn mpls
EVPN-MPLS Information
=================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VPN-ID   EVI-Name     EVI-Type Type Interface ESI                            VLAN DF-Status Src-Addr         Dst-Addr
_____________________________________________________________________________________________________________________________
___
6001     ----         L2       NW   ----      ----                           ---- ----      102.1.1.1        101.1.1.1
6001     ----         L2       NW   ----      ----                           ---- ----      102.1.1.1        105.1.1.1
6001     ----         --       AC   xe1.301   --- Single Homed Port ---      ---- ----      ----             ----
6001     ----         --       AC   po10.301  00:00:00:00:00:15:15:00:00:00 ---- DF        ----             ----
6002     ----         L2       NW   ----      ----                           ---- ----      102.1.1.1        101.1.1.1
6002     ----         L2       NW   ----      ----                           ---- ----      102.1.1.1        105.1.1.1
6002     ----         --       AC   po10.302  00:00:00:00:00:15:15:00:00:00 ---- NON-DF    ----             ----

Total number of entries are 7
MH-PE2#
```

show evpn mpls arp-cache

Use this command to display the ARP cache information.

Command syntax

```
show evpn mpls arp-cache (|evid <1-16777215>) summary
```

Parameters

`evid`	EVPN-MPLS tenant identifier
`<1-16777215>`	Range supported for EVID
`summary`	Ethernet Virtual Private Network ID

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
PE1#show evpn mpls arp-cache
MPLS-EVPN ARP-CACHE Information
===============================
EVPN-ID   Ip-Addr          Mac-Addr        Type        Age-Out   Retries-Left
_____________________________________________________________________________
2001     122.122.122.1    0000.0000.1111 Dynamic Local   ----
2001     122.122.122.2    0000.0000.2222 Dynamic Remote  ----
Total number of entries are 2
PE1#
```

show evpn mpls counters

This command to display the ingress/egress evpn-mpls network port statistic counters for both BUM and known unicast data traffic.

Note: To see the statistics, you must enable the command `hardware-profile statistics evpn-mpls enable` and reboot the board for the command to take effect.

Command syntax

```
show evpn mpls counters ((network (ingress|(egress dst <A.B.C.D>)))| vpn-id <1-
  16777215> (network (ingress|(egress dst <A.B.C.D>))))
```

Parameters

`<1-16777215>`	VPN identifier
`A.B.C.D`	Ipv4 address

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
DUT2#show evpn mpls counters network egress
+----------+---------------+-----------+-----------+
|  VPN-ID  |  DESTINATION  |    BUM    |  Unicast  |
|          |     PEER      | TX (pkts) | TX (pkts) |
+----------+---------------+-----------+-----------+
 2000       2.2.2.2         140136      68900
 1999       2.2.2.2         140138      68899
 1998       2.2.2.2         140136      68899
 1997       2.2.2.2         140137      68897
DUT2#
DUT2#show evpn mpls counters network ingress
+----------+-----------+-----------+
|  VPN-ID  |    BUM    |  Unicast  |
|          | RX (pkts) | RX (pkts) |
+----------+-----------+-----------+
 30         0           800122
 10         0           727383
 4001       5           727362
 3003       0           0
 3002       727368      0
 3001       3           727364
DUT2#
```

show evpn mpls label alias

Use this command to display the alias label details of the MH Nodes.

Command syntax

```
show evpn mpls label alias
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
Remote-PE3#sh evpn mpls label alias
S - Self
R - Remote
ESI                              PE-IP-ADDRESS        TENANT              ALIAS-LABEL
=================================================================================
00:00:00:00:00:15:15:00:00:00  101.1.1.1(R)        6001                    18
00:00:00:00:00:15:15:00:00:00  101.1.1.1(R)        6002                    20
00:00:00:00:00:15:15:00:00:00  101.1.1.1(R)          11                    19
00:00:00:00:00:15:15:00:00:00  102.1.1.1(R)        6001                    19
00:00:00:00:00:15:15:00:00:00  102.1.1.1(R)        6002                    20
00:00:00:00:00:15:15:00:00:00  102.1.1.1(R)          11                    18
Remote-PE3#
Remote-PE3#
```

show evpn mpls label esi

Use this command to display the esi label details of MH Nodes.

Command syntax

```
show evpn mpls label esi
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Examples

```
MH-PE1#sh evpn mpls label esi
S - Self
R - Remote
ESI                               PE-IP-ADDRESS        ESI-LABEL
================================================================
00:00:00:00:00:13:13:00:00:00  101.1.1.1(S)           38
00:00:00:00:00:13:13:00:00:00  102.1.1.1(R)           43
00:00:00:00:00:15:15:00:00:00  101.1.1.1(S)           37
00:00:00:00:00:15:15:00:00:00  102.1.1.1(R)           42
```

show evpn mpls mac-table

Use this command to display the host MAC address table.

Command Syntax

```
show evpn mpls mac-table (|evid <1-16777215>|) (summary | hardware |)
```

Parameters

`<1-16777215>` EVPN-MPLS tenant identifier

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
PE1#sh evpn mpls mac-table
==============================================================================================================================
=========================
                                                         EVPN MPLS MAC Entries
==============================================================================================================================
=========================
VNID      Interface VlanId Inner-VlanId Mac-Addr      VTEP-Ip/ESI                  Type               Status          Time-
out AccessPortDesc
______________________________________________________________________________________________________________________________
_________________________

2001      ----       ----   ----        0000.0000.aa21 101.1.1.1                   Dynamic Remote      -------             -
------
2001      xe1.14     ----   ----        0000.0000.bb21 105.1.1.1                   Dynamic Local       -------             -
------
1001      ----       ----   ----        0000.0000.aa11 101.1.1.1                   Dynamic Remote      -------             -
------
1001      xe1.2      ----   ----        0000.0000.bb11 105.1.1.1                   Static Local        -------             -
------

Total number of entries are : 4

PE1#
```

show evpn mpls nd-cache

Use this command to display the ND cache information.

Command Syntax

```
show evpn mpls nd-cache (|evid <1-16777215>) summary
```

Parameters

`evid`	EVID
`<1-16777215>`	Range supported for EVID
`summary`	Ethernet Virtual Private Network ID

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
PE1#
PE1#show evpn mpls nd-cache
MPLS-EVPN ND-CACHE Information
==============================
EVPN-ID  Ip-Addr                      Mac-Addr         Type         Age-Out
Retries-Left
_______________________________________________________________________________
_______________
1001     1201::1                       0000.0000.cc10 Dynamic Local    ----
1001     1201::2                       0000.0000.dd10 Dynamic Remote   ----
Total number of entries are 2
PE1#
PE1#
```

show evpn mpls route-count

Use this command to display the evpn active route (MAC-IP.MAC-IPv6 and MAC-only) count information.

Command Syntax

```
show evpn mpls route-count (|evid <1-16777215>)
```

Parameters

`evid`	EVPN-MPLS tenant identifier

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
PE1#show evpn mpls route-count
EVPN-MPLS Active route count information
====================================
Max route count    : 32768
Active route count: 6

---------------------------------------------
 VNID      Total     MACONLY  MACIPv4  MACIPv6
---------------------------------------------
 6001      3         1        1        1
 7001      3         1        1        1

Total number of entries are 2
PE1#
```

Table 4-14 explains the output fields.

Table 4-14: show evpn mpls route-count fields

Field	Description
Max route count	Maximum number of route count in evpn mpls.
Active route count	Number of active route count in the interface.
VNID	VNID is used to identify Layer 2 segments and to maintain Layer 2 isolation between the segments.
Total	Total number of entries for the interface.
MACONLY	The MAC-only route for both the local and the remote entries in the EVPN MPLS instance route table.

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Table 4-14: show evpn mpls route-count fields

Field	Description
MACIPv4	IPv4 media access control (MAC) address for a default virtual gateway.
MACIPv6	IPv6 media access control (MAC) address for a default virtual gateway.

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show evpn mpls static host state

Use this command to display the state of the host which is configured statically.

Command Syntax

```
show evpn mpls static host state
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
MH-PE2#sh evpn mpls static host status
MPLS Static Host Information
=============================
   Codes: NW - Network Port
          AC - Access Port
         (u) - Untagged

VNID     Ifname       Outer-Vlan Inner-vlan Ip-Addr                                 Mac-Addr       Status
_____________________________________________________________________________________________________________
6001     po10.301     ---        ---        0.0.0.0                                 0000.0000.aa11 Active
6001     po10.301     ---        ---        12.12.12.10                             0000.0000.aa12 Active
6001     po10.301     ---        ---        1201::10                                0000.0000.aa13 Active

Total number of entries are 3
MH-PE2#
```

show evpn mpls status

Use this command to display EVPN MPLS status in hardware.

Command Syntax

```
show evpn mpls status
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
PE-1#show evpn mpls status
EVPN-MPLS is ACTIVE in Hardware
```

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show evpn mpls tunnel

Use this command to view the active EVPN MPLS tunnels for ELAN.

Command Syntax

```
show evpn mpls tunnel (| summary)
```

Parameters

`summary`	Summary information

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Example

```
PE1#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=================================================================================
101.1.1.1        105.1.1.1        Installed     00:43:09      00:43:09      2001
101.1.1.1        105.1.1.1        Installed     00:43:09      00:43:09      1001

Total number of entries are 2
PE1#
```

show evpn mpls tunnel label

Use this command to display the label details of the EVPN tunnels.

Command Syntax

```
show evpn mpls tunnel label
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0 and RSVP multipath was introduced in OcNOS version 5.0.

Example

```
PE1#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+=========+===============+=========+=========+=========+=========+============+========+======
======+========
                                                                                     Local            Remote           RSVP-Multipath         Underlay
Destination     Status      VPN-ID    Policy         MC-Label  UC-Label  MC-Label  UC-Label  Grp-Name     NHLFE-ix  NW-Intf
NW-Label
================+===========+=========+===============+=========+=========+=========+=========+============+========+======
======+========
3.3.3.3         Installed   601       --              640       17        640       17        --           --        xe10
24320
3.3.3.3         Installed   801       --              641       18        641       18        --           --        xe10
24320
4.4.4.4         Installed   1601      --             642       20        640       17        MP1         12        NA          NA
4.4.4.4         Installed   1801      --             643       21        641       18        MP1         12        NA          NA

Total number of entries are 4
PE1#
```

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show evpn mpls xconnect

Use this command to display the VPWS xconnect details of the MTU, AC-NW connections, and network status.

Command Syntax

```
show evpn mpls xconnect
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
Remote-PE3#sh evpn mpls xconnect
EVPN-MPLS Xconnect Info
========================
AC-AC: Local-Cross-connect
AC-NW: Cross-connect to Network
AC-UP: Access-port is up
AC-DN: Access-port is down
NW-UP: Network is up
NW-DN: Network is down
NW-SET: Network and AC both are up

Local                            Remote       Connection-Details
================================ ============
=====================================================================================
VPN-ID      EVI-Name      MTU   VPN-ID       Source       Destination                  PE-IP          MTU   Type   NW-Status
================================ ============
=====================================================================================
11          ----          1500  10           xe1.10       00:00:00:00:00:15:15:00:00:00 102.1.1.1       1500  AC-NW  NW-SET
                                                                                       101.1.1.1       1500  ----   ----
40          ----          1500  30           xe2.2        --- Single Homed Port ---     102.1.1.1       1500  AC-NW  NW-SET

Total number of entries are 2
Remote-PE3#
```

show evpn mpls xconnect tunnel

Use this command to view the active EVPN MPLS Tunnels for ELINE.

Command Syntax

```
show evpn mpls xconnect tunnel (| summary)
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
PE1#
PE1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        local-evpn-id remote-evpn-id
=========================================================================================================
101.1.1.1        105.1.1.1        Installed     01:25:48      01:25:48      50           60
101.1.1.1        105.1.1.1        Installed     00:07:53      00:07:53      30           40
101.1.1.1        105.1.1.1        Installed     00:07:55      00:07:55      10           20

Total number of entries are 3
PE1#
```

show evpn mpls xconnect tunnel label

Use this command to display the label details of EVPN tunnels for ELINE.

Command Syntax

```
show evpn mpls xconnect tunnel label
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0 and RSVP-Multipath is introduced in OcNOS version 5.0.

Example

```
PE1#
PE1#show evpn mpls xco tunnel label
EVPN-MPLS Network tunnel labels
(*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+=========+=========+===============+=========+=========+============+=========+============+===
======
                             Local     Remote                       Local     Remote      RSVP-Multipath          Underlay
Destination     Status      VPWS-ID   VPWS-ID   Policy         UC-Label  UC-Label  Grp-Name     NHLFE-ix  NW-Intf      NW-Label
================+===========+=========+=========+===============+=========+=========+============+=========+============+===
======
3.3.3.3          Installed   501       1         --              16        16        MP2          10         NA           NA
4.4.4.4          Installed   1501      1001      --              19        16        --           --         xe10         24320

Total number of entries are 2
PE1#
```

show running-config evpn mpls

Use this command to display the current running configuration of EVPN MPLS.

Command Syntax

```
show running-config evpn mpls
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#show running-config evpn mpls
!
evpn mpls enable
!
evpn mpls vtep-ip-global 101.1.1.1
!
evpn mpls multihoming enable
!
evpn esi hold-time 30
!
evpn mpls mac-ageing-time 180
!
evpn mpls arp-nd refresh-timer 60
!
evpn mpls id 10 xconnect target-mpls-id 20
 host-reachability-protocol evpn-bgp l2vrf5
!
vpn-id 1001
 host-reachability-protocol evpn-bgp l2vrf1
 mac-holdtime 300
 evi-name ELANE
!
interface xe1.2 switchport
 access-if-evpn
  map vpn-id 1001
  dynamic-learning disable
  arp-nd flood-suppress
  mac-holdtime 200
  arp-cache disable
  nd-cache disable
  mac 0000.0000.aa31
  mac 0000.0000.aa32 ip 12.12.12.10
  mac 0000.0000.aa33 ipv6 1201::1
!
interface xe1.10 switchport
```

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```
 encapsulation dot1q 10
 access-if-evpn
  map vpn-id 10
!
```

tunnel-select-policy

Use this command to associate tunnel-policy to an EVPN instance and to a mac-vrf. This will be used while selecting transport for EVPN service. In particular, an EVPN instance could be either an ELINE or ELAN type and may also multi-homing also enabled.

Use the `no` parameter with this command to un-configure tunnel-policy from the EVPN instance.

Please refer MPLS Service Mapping Configuration for Tunnel-policy Name configuration.

Command Syntax

```
tunnel-select-policy NAME
no tunnel-select-policy
```

Parameters

NAME	Name of tunnel-policy

Command Mode

EVPN MPLS Config mode and MAC_VRF MODE

Note:

Applicability

This command was introduced in OcNOS version 4.1 but the support for this CLI under mac-vrf mode is introduced in OcNOS-SP version 4.2.

Examples

```
#configure terminal
(config)#mac vrf vrf1
(config-vrf)# tunnel-select-policy policy1
(config-vrf)#end
(config)# evpn mpls id 1001
(config-evpn-mpls)# tunnel-select-policy policy2
(config-evpn-mpls)# end
(config)# evpn mpls id 10 xconnect target-mpls-id 20
(config-evpn-mpls)# tunnel-select-policy policy3
(config-evpn-mpls)# end
```

CHAPTER 5 MPLS Service Mapping Commands

This chapter describes each MPLS Service Mapping command.

- color
- mode
- mpls 6pe tunnel-select-policy
- show running-config tunnel-policy
- show tunnel-policy
- tunnel-policy
- tunnel-select-policy (For L3VPN service)

color

Use this command to set color value for a tunnel policy. This value will be used while selecting transport for given service.

Use the `no` parameter with this command to un-configure color value for tunnel policy.

Command Syntax

```
color <1-4294967295>
no color <1-4294967295>
```

Parameters

`color`	Configure color code

Command Mode

Tunnel policy mode

Applicability

This command was introduced in OcNOS version 4.2.

Example

```
#configure terminal
(config)#tunnel-policy policy1
(config-tnl-policy)#color 23
```

mode

Use this command to set tunnel selection mode for a tunnel policy. This will be used while selecting transport for given service. Mode can be dedicated or best-effort.

Use the `no` parameter with this command to set mode to default mode.

Command Syntax

```
mode dedicated|best-effort
no mode
```

Parameters

`best-effort`	Best effort tunnel selection mode
`dedicated`	Dedicated tunnel selection mode (Default)

Default

Dedicated

Command Mode

Tunnel policy mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)#tunnel-policy policy1
(config-tnl-policy)# mode best-effort
```

mpls 6pe tunnel-select-policy

Use this command to set tunnel-policy for a 6PE services. This will be used while selecting transport for 6PE services. Use the `no` parameter with this command to unconfigure tunnel selection policy for 6PE.

Command Syntax

```
mpls 6pe tunnel-select-policy NAME
```

Parameters

NAME	Name of tunnel-policy

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)# mpls 6pe tunnel-select-policy policy1
```

show running-config tunnel-policy

Use this command to display the current running configuration of all tunnel policies.

Command Syntax

```
show running-config tunnel-policy
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#show running-config tunnel-policy
!
tunnel-policy tp1
 color 1
!
```

show tunnel-policy

Use this command to display the tunnel policy details.

Command Syntax

```
show tunnel-policy (NAME (service (((6pe|vpls|vpws|evpn|l3vpn|) details)) |
  (count)))| service details |)
```

Parameters

`NAME`	show tunnel policy table by name
`service`	show service information
`6pe`	Display 6PE service details
`evpn`	Display EVPN service details
`l3vpn`	Display L3VPN service details
`vpls`	Display VPLS service details
`vpws`	Display VPWS service details
`count`	show counts
`details`	show details
`service`	show service information
`details`	show details

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

The following sample shows the summary of all configured tunnel policies.

```
#show tunnel-policy
tunnel-policy tp1
  color 1
  tunnel-mode dedicated
  tunnel-type any
Total Services attached:
  VRF         : 1
  VPWS    : 1
  VPLS      : 1
  EVPN     :
```

The following sample shows the summary of specific configured tunnel policy by name.

```
#show tunnel-policy tp1
tunnel-policy tp1
```

```
    color 1
    tunnel-mode dedicated
    tunnel-type any
  Total Services attached:
    VRF        : 1
    VPWS    : 1
    VPLS      : 1
    EVPN     : 0
```

The following sample shows the detailed information of all the configured tunnel policies.

```
#show tunnel-policy service details
List of services configured with tunnel-policy tp1:
  VPWS
   VPWS-Id: 100, Name: vpws1 Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
  L3VPN
   VRF id 2
    FTN id: 1, Prefix: 20.10.30.0/24, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
    FTN id: 2, Prefix: 3001::/64, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
  VPLS
   VPLS-Id: 300, Name: vpls1, Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
```

The following sample shows the detailed information of specific configured tunnel policy by name.

```
# show tunnel-policy tp1 service details
Total services using tunnel-policy tp1:
  VPWS
   VPWS-Id: 100, Name: vpws1 Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
  L3VPN
   VRF id 2
    FTN id: 1, Prefix: 20.10.30.0/24, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
    FTN id: 2, Prefix: 3001::/64, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
  VPLS
   VPLS-Id: 300, Name: vpls1, Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
```

The following sample shows the services count of specific tunnel policy by name.

```
#show tunnel-policy tp1 service count
Total services using tunnel-policy tp1:
  VPWS   : 1
  VPLS     : 0
  L3VPN  : 2
  6PE       : 0
  EVPN    : 0
```

The following sample shows the detailed VPLS service information of specific tunnel policy by name.

```
#show tunnel-policy tp1 service vpls details
Total services using tunnel-policy tp1:
  VPLS
```

```
  VPLS-Id: 300, Name: vpls1, Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
```

The following sample shows the detailed VPWS service information of specific tunnel policy by name.

```
#show tunnel-policy tp1 service vpws details
Total services using tunnel-policy tp1:
  VPWS
   VPWS-Id: 100, Name: vpws1 Status: UP, Mapped Tunnel: RSVP, ftn_ix 4, color
1
```

The following sample shows the detailed L3VPN service information of specific tunnel policy by name.

```
#show tunnel-policy tp1 service l3vpn details
Total services using tunnel-policy tp1:
  L3VPN
   VRF id 2
    FTN id: 1, Prefix: 20.10.30.0/24, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
    FTN id: 2, Prefix: 3001::/64, Status: Up, Label: 25664, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
```

The following sample shows the detailed 6PE service information of specific tunnel policy by name.

```
#show tunnel-policy tp1 service 6pe details
Total services using tunnel-policy tp1:
  6PE
   FTN id: 3, Prefix: 3002::/64, Status: Up, Label: 25665, Mapped Tunnel:
RSVP, ftn_ix 4, color 1
```

The following sample shows the detailed EVPN service information of specific tunnel policy by name.

```
#show tunnel-policy tp1 service evpn details
Total services using tunnel-policy tp1:
  EVPN
   EVPN-Id: 30, Tunnel count: 1
   Peer: 105.1.1.1, Mapped Tunnel: SR_POLICY, ftn_ix 3, color 202
   EVPN-Id: 1001, Tunnel count: 2
   Peer: 105.1.1.1, Mapped Tunnel: SR_POLICY, ftn_ix 3, color 202   Peer:
101.1.1.1, Mapped Tunnel: SR_POLICY, ftn_ix 4, color 204
```

tunnel-policy

Use this command to create a tunnel policy.

Use the `no` parameter with this command to un-configure the tunnel policy. Tunnel policy can be un-configured only if no service is using it.

Command Syntax

```
tunnel-policy NAME
no tunnel-policy NAME
```

Parameters

NAME	Name to be used for tunnel policy

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.2.

Example

```
#configure terminal
(config)#tunnel-policy policy1
```

tunnel-select-policy (For L3VPN service)

Use this command to set tunnel-policy for a VRF instance. This will be used while selecting transport for L3VPN service.

Use the `no` parameter with this command to un-configure tunnel-policy from VRF instance.

Command Syntax

```
tunnel-select-policy NAME
no tunnel-select-policy
```

Parameters

NAME	Name of tunnel-policy

Command Mode

IP VRF mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)#ip vrf vrf1
(config-vrf)#tunnel-select-policy policy1
```

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CHAPTER 6 MPLS LSP BFD Commands

This chapter describes each ICCP (Inter-Chassis Communication Protocol) command.

lsp ping-interval

Use this command to configure periodic MPLS ping echo request for BFD session over MPLS LSP.

Use `no` form of the command to set default periodic MPLS ping echo request interval.

Command Syntax

```
lsp-ping-interval <0-1000>
no lsp-ping-interval
```

Parameters

`<0-1000>`	Ping interval in sec

Command Mode

MPLS BFD mode.

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)# lsp-ping-interval 10
```

min-tx

Use this command to configure BFD transmit and receive intervals, and the hello multiplier value for MPLS LSP BFD session.

Use the `no` form of the command to set the intervals and multiplier to their default values.

Command Syntax

```
min-tx <50-999> min-rx <50-999> multiplier <3-50>
no min-tx <50-999> min-rx <50-999> multiplier <3-50>
```

Parameters

`min-tx`	Set BFD Min Tx interval
`<50-999>`	Desired Tx interval in ms.
`min-rx`	Set BFD Min Rx interval
`<50-999>`	Desired Rx interval in ms.
`Multiplier`	Set BFD Detection Multiplier
`<3-50>`	Multiplier value

Defaults

The default for the transmit and receive intervals is 10 milliseconds. The default hello multiplier value is 3.

Command Mode

MPLS BFD mode.

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)# min-tx 10 min-rx 10 multiplier 3
```

mpls bfd

Use this command to configure BFD session for MPLS LSP.

Use `no` form of the command to unconfigure BFD session from MPLS LSP.

Command Syntax

```
mpls bfd ((ldp A.B.C.D/M)|(rsvp tunnel-name NAME)|(static A.B.C.D/M))
mpls bfd (ldp|rsvp|static) all
no mpls bfd ((ldp A.B.C.D/M)|(rsvp tunnel-name NAME)|(static A.B.C.D/M))
no mpls bfd (ldp|rsvp|static) all
```

Parameters

`ldp`	LDP type LSP
`A.B.C.D/M`	LDP FEC
`all`	All LSPs
`rsvp`	RSVP type LSP
`tunnel-name`	RSVP Tunnel
`all`	All LSPs
`static`	Static type LSP
`A.B.C.D/M`	Static FEC
`all`	All LSPs

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)#
```

shutdown

Use this command to configure MPLS LSP BFD session in Admin Down state or to disable BFD session.

Use `no` form of the CLI to enable BFD session.

Command Syntax

```
shutdown
no shutdown
```

Parameters

None

Command Mode

MPLS BFD mode.

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#configure terminal
(config)# mpls bfd ldp all
(config-mpls-bfd)# shutdown
```

CHAPTER 7 L2VPN over L2 Subinterface Commands

This chapter is a reference for the L2VPN commands over L2 subinterface.

VPWS:

- access-if-vpws
- mpls-l2-circuit
- vc-mode

VPLS:

- access-if-vpls
- mpls-vpls
- learning disable
- split-horizon (subinterface)
- static-mac

access-if-vpws

Use this command in L2 subinterface mode to create the vpws access-port.

Use the `no` form of this command to delete the vpws access port.

Command Syntax

```
access-if-vpws
no access-if-vpws
```

Parameters

None

Command Mode

L2 Sub-interface mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpws
(config-acc-if-vpws)#end
```

mpls-l2-circuit

Use this command to bind am mpls-l2-circuit to an L2 subinterface

Use the `no` form of this command to unbind an mpls-l2-circuit from an L2 subinterface

Command Syntax

```
mpls-l2-circuit NAME (primary | secondary)
no mpls-l2-circuit NAME
```

Parameters

`NAME`	A string identifying the MPLS Layer-2 Virtual Circuit
`primary`	Identify L2 circuit as the primary link
`secondary`	Identify L2 circuit as the secondary link; the secondary link is not activated unless the primary link fails

Command Mode

access-if-vpws mode

Applicability

This command w as introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpws
(config-acc-if-vpws)#mpls-l2-circuit vc1 primary
(config-acc-if-vpws)#mpls-l2-circuit vc2 secondary
(config-acc-if-vpws)#end
```

vc-mode

Use this command to configure vc-mode as revertive for an mpls l2-circuit.

Use the `no` form of this command to remove the vc-mode.

Command Syntax

```
vc-mode revertive
no vc-mode revertive
```

Parameters

None

Command Mode

access-if-vpws mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpws
(config-acc-if-vpws)#mpls-l2-circuit vc1 primary
(config-acc-if-vpws)#mpls-l2-circuit vc2 secondary
(config-acc-if-vpws)#vc-mode revertive
(config-acc-if-vpws)#end
```

access-if-vpls

Use this command in L2 subinterface mode to create the vpls access-port.

Use the `no` form of this command to delete the vpls access port

Command Syntax

```
access-if-vpls
no access-if-vpls
```

Parameters

None

Command Mode

L2 Sub-interface mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#end
```

mpls-vpls

Use this command to bind a VPLS instance to an L2 subinterface.

Use the `no` form of this command to unbind vpls instance from a L2 subinterface.

Command Syntax

```
mpls-vpls NAME
no mpls-vpls NAME
```

Parameters

NAME	VPLS instance name

Command Mode

access-if-vpls mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.2 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#mpls-vpls v100
(config-acc-if-vpls)#end
```

learning disable

Use this command to disable learning on a particular Attachment Circuit (AC) interface.

Use the `no` form of this command to enable learning on a particular AC interface.

Note: This command disables MAC learning only on that interface.

Command Syntax

```
learning disable
no learning disable
```

Parameters

None

Command Mode

access-if-vpls mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.2 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#learning disable
(config-acc-if-vpls)#end
```

split-horizon (subinterface)

Use this command to configure split-horizon group for L2 sub-interface.

Use the `no` form of this command to remove split-horizon group from L2 sub-interface.

Command Syntax

```
split-horizon group (network | access1 | access2)
no split-horizon group
```

Parameters

`network`	Split-horizon group name network
`access1`	Split-horizon group name access1
`access2`	Split-horizon group name access2

Default

By default, split horizon is disabled.

Command Mode

Interface mode

Applicability

This command was introduced in OcNOS version 6.3.0 and applicable only on Qumran1 devices..

Examples

```
#configure terminal
(config)#interface xe1.1 switchport
(config-if)#split-horizon group access1
(config-if)#no split-horizon group
```

static-mac

Use this command to add a static MAC address to an attachment circuit specific for a VPLS instance.

Use the `no` parameter with this command to remove static MAC address.

Command Syntax

```
static-mac XXXX.XXXX.XXXX
no static-mac XXXX.XXXX.XXXX
```

Parameters

`XXXX.XXXX.XXXX` MAC address in HHHH.HHHH.HHHH format

Command Mode

access-if-vpls mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#interface xe1.2 switchport
(config-if)#access-if-vpls
(config-acc-if-vpls)#static-mac 0091.0000.1010
(config-acc-if-vpls)#end
```

Layer 2 Virtual Private network Configuration

CHAPTER 1 L2VPN FAT SUPPORT

This chapter contains configurations of L2VPN with FAT support.

This is a functional level test plan scoped for the Flow-Aware Transport (FAT) of pseudowire (PW) over an MPLS packet switched network for load-balancing traffic across LDP-based signaled pseudowire for Virtual Private LAN Services (VPLS) and Virtual Private Wire Service (VPWS).

Topology

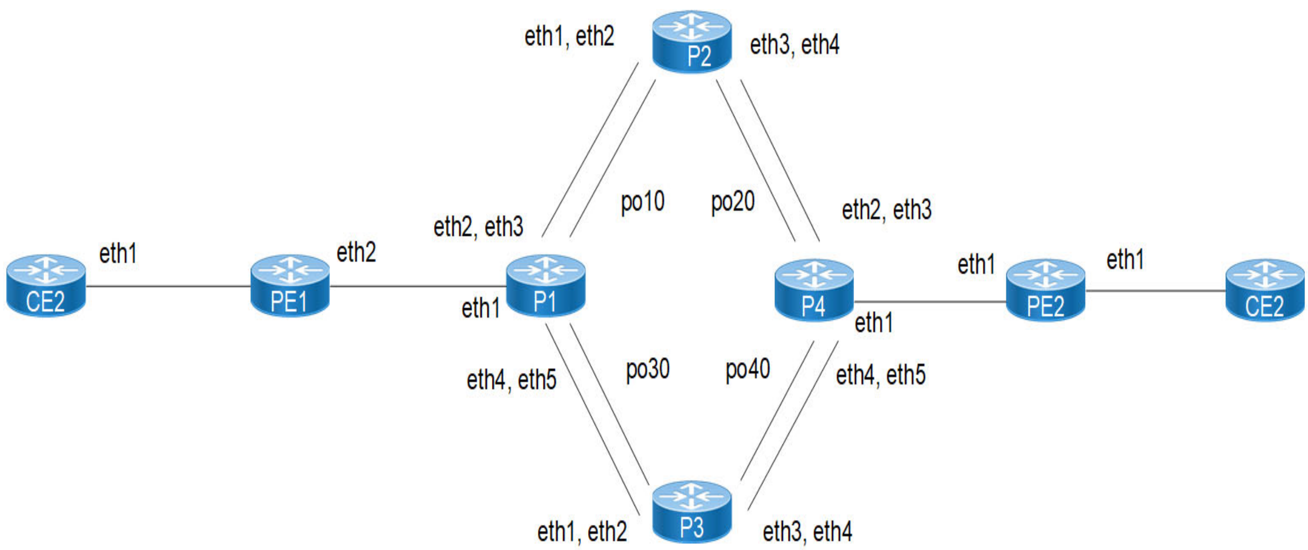

Figure 1-12: L2VPN configuration topology

Configuration for VPLS with FAT

PE-1

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 1.1.1.1/32 secondary`	Configure IP address for the loopback interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 1.1.1.1`	Configure Router-id
`(config-router)#targeted-peer ipv4 6.6.6.6`	Configuring targeted LDP sessions to PE-2
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted-peer mode

(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.1.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 1.1.1.1	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#mpls vpls vpls100 100	Configuring VPLS instance with name and VPLS ID
PE1(config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#vpls-peer 6.6.6.6	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface eth2.100 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vpls100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode

P1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id

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(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.1.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.

(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 3.3.3.3	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the
area ID (0) with the interface.	
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the
area ID (0) with the interface.	
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 4.4.4.4	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer, identifying the routing process
(config-router)#ospf router-id 4.4.4.4	Configure ospf Router-id
(config-router)#network 10.1.3.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 5.5.5.5	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.6.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2

(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 5.5.5.5	Configure ospf Router-id
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

PE-2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 6.6.6.6/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 6.6.6.6	Configure Router-id
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode

(config-router)#transport-address ipv4 6.6.6.6	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface eth2	Enter interface mode
(config-if)#ip address 10.1.6.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the Process ID(100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 6.6.6.6	Configure ospf Router-id
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 6.6.6.6/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls vpls vpls100 100	Configuring VPLS instance with name and VPLS ID
PE1(config-vpls)#flow-label both	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#vpls-peer 1.1.1.1	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface eth2.100 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vpls100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode

Validation

PE1

```
---
PE1#show mpls vpls bgp_vpls100 mesh
(m) - Service mapped over multipath transport

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
```

```
100       6.6.6.6      24961        24963     xe4          24963      2/Up      1
LDP           Active
PE1#
PE1#show mpls vpls vpls100 detail
Virtual Private LAN Service Instance: vpls100, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Enabled, Direction: Both, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe18.100
 Subinterface Match Criteria(s) :
  dot1q 100
 Mesh Peers:
   6.6.6.6 (Up)


#ping mpls vpls 200 peer 6.6.6.6/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

 !
 !
 !
 !
 !

Success Rate is 100.00 percent (5/5)
```

PE2

```
===
PE2#show mpls vpls vpls200 mesh
(m) - Service mapped over multipath transport
```

```
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
200       1.1.1.1      24961        24963     xe4           24963     2/Up     1
BGP            Active
PE2#
PE1#show mpls vpls vpls100 detail
Virtual Private LAN Service Instance: vpls100, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Enabled, Direction: Both, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe18.100
 Subinterface Match Criteria(s) :
  dot1q 100
 Mesh Peers:
   1.1.1.1 (Up)


#ping mpls vpls 200 peer 1.1.1.1/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

 !
 !
 !
 !
 !

Success Rate is 100.00 percent (5/5)
```

P1

```
==
P1#clear interface counters
```

```
P1#show interface counters rate mbps
+-------------------+--------------+-------------+--------------+-------------+
|     Interface     |    Rx mbps   |    Rx pps   |    Tx mbps   |    Tx pps   |
+-------------------+--------------+-------------+--------------+-------------+
 Po10                1549.80        1265260       1034.60        844649
 Po30                0.01           8             0.00           8
 xe4                 1034.60        844647        1549.80        1265257
 xe10                0.00           0             0.00           0
 xe11                0.00           0             0.00           0
 xe12                943.60         773213        474.05         384785
 xe13                0.00           4             0.00           4
 xe16                606.20         492047        560.54         459865
 xe17                0.00           0             0.00           0
 xe19                0.00           4             0.00           4
P1#
```

P4

```
==
P4#clear interface counters

P4#show interface counters rate mbps
+-------------------+--------------+-------------+--------------+-------------+
|     Interface     |    Rx mbps   |    Rx pps   |    Tx mbps   |    Tx pps   |
+-------------------+--------------+-------------+--------------+-------------+
 Po20                1549.80        1265260       1034.60        844649
 Po40                0.01           8             0.00           8
 xe4                 1034.60        844647        1549.80        1265257
 xe10                0.00           0             0.00           0
 xe11                0.00           0             0.00           0
 xe12                943.60         773213        474.05         384785
 xe13                0.00           4             0.00           4
 xe16                606.20         492047        560.54         459865
 xe17                0.00           0             0.00           0
 xe19                0.00           4             0.00           4
P1#
```

Configuration for BGP VPLS with FAT

PE-1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP

`(config-router)#router-id 1.1.1.1`	Configure Router-id
`(config-router)#targeted-peer ipv4 6.6.6.6`	Configuring targeted LDP sessions to PE-2
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted-peer mode
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#interface eth2`	Enter interface mode
`(config-if)#ip address 10.1.1.1/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#ospf router-id 1.1.1.1`	Configure ospf Router-id
`(config-router)#network 10.1.1.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 1.1.1.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.
`(config-router)#exit`	Exit from router mode
`(config)#mpls vpls bgp_vpls200 200`	Configuring VPLS instance with name and VPLS ID
`PE1(config-vpls)#flow-label both`	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
`(config-vpls)#signaling bgp`	Enabling BGP signaling for the VPLS instance
`(config-vpls-sig)#ve-id 500`	Configure VE ID, which is mandatory for BGP VPLS, otherwise, Signaling does not take place. VE ID should be unique per VPLS instance.
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode
`(config-vpls)#exit-vpls`	Exit from VPLS mode
`(config-if)#interface eth2.200 switchport`	Enter sub interface mode
`(config-if)#encapsulation dot1q 200`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpls`	Access VPLS under sub interface
`(config-acc-if-vpls)#mpls-vpls bgp_vpls200`	Associating the VPLS Instance to the attachment circuit interface.
`(config-acc-if-vpls)#commit`	Commit the configuration
`(config-acc-if-vpls)#end`	Return to privilege mode
`#configure terminal`	Enter configuration mode.
`(config)#router bgp 100`	Enter BGP router mode.
`(config-router)#neighbor 6.6.6.6 remote-as 100`	Configure PE2 as an iBGP peer.

(config-router)#neighbor 6.6.6.6 updatesource lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#address-family l2vpn vpls	Configure address-family l2vpn vpls.
(config-router-af)#neighbor 6.6.6.6 activate	Activate PE2 in the VPLS address family.
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#exit	Exit router mode.

P1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.1.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

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(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 3.3.3.3	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode

(config)#commit	Commit the transaction.
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 4.4.4.4	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 4.4.4.4	Configure ospf Router-id
(config-router)#network 10.1.3.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 5.5.5.5	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode

(config-if)#ip address 10.1.6.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 5.5.5.5	Configure ospf Router-id
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.5.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.6.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 5.5.5.5/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

PE-2

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 6.6.6.6/32 secondary`	Configure IP address for the loopback interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 6.6.6.6`	Configure Router-id
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configuring targeted LDP sessions to PE-2
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted-peer mode
`(config-router)#transport-address ipv4 6.6.6.6`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#interface eth2`	Enter interface mode
`(config-if)#ip address 10.1.6.2/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#ospf router-id 6.6.6.6`	Configure ospf Router-id
`(config-router)#network 10.1.6.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 6.6.6.6/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#mpls vpls bgp_vpls200 200`	Configuring VPLS instance with name and VPLS ID
`PE1(config-vpls)#flow-label both`	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
`(config-vpls)#signaling bgp`	Enabling BGP signaling for the VPLS instance
`(config-vpls-sig)#ve-id 600`	Configure VE ID, which is mandatory for BGP VPLS, otherwise, Signaling does not take place. VE ID should be unique per VPLS instance.
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode
`(config-vpls)#exit-vpls`	Exit from VPLS mode
`(config-if)#interface eth2.200 switchport`	Enter sub interface mode
`(config-if)#encapsulation dot1q 200`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpls`	Access VPLS under sub interface

(config-acc-if-vpls)#mpls-vpls bgp_vpls200	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode
(config)#router bgp 100	Enter BGP router mode.
(config-router)#neighbor 1.1.1.1 remote-as 100	Configure PE1 as an iBGP peer.
(config-router)#neighbor 1.1.1.1 updatesource lo	Update the source as loopback for iBGP peering with the remote PE1 router.
(config-router)#address-family l2vpn vpls	Configure address-family l2vpn vpls.
(config-router-af)#neighbor 1.1.1.1 activate	Activate PE1 in the VPLS address family.
(config-router-af)#exit-address-family	Exit address family mode
(config-router)#exit	Exit router mode.

Validation

PE1

```
---
PE1#show mpls vpls bgp_vpls200 mesh
(m) - Service mapped over multipath transport

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
200       6.6.6.6      24961        24963     xe4           24963     2/Up     1
BGP            Active
PE1#
PE1#show mpls vpls bgp_vpls200 detail
Virtual Private LAN Service Instance: bgp_vpls200, ID: 200
 SIG-Protocol: BGP
  Route-Distinguisher :100:200
  Route-Target :100:200
  VE-ID :500
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Enabled, Direction: Receive, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: eth1.200
 Subinterface Match Criteria(s) :
  dot1q 300
 Mesh Peers:
   6.6.6.6 (Up)
```

```
#ping mpls bgp_vpls 200 peer 6.6.6.6/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

  !
  !
  !
  !
  !

Success Rate is 100.00 percent (5/5)
```

PE2

```
===
PE2#show mpls vpls bgp_vpls200 mesh
(m) - Service mapped over multipath transport

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
200       1.1.1.1      24961        24963     xe4           24963     2/Up     1
BGP            Active
PE2#
PE1#show mpls vpls bgp_vpls200 detail
Virtual Private LAN Service Instance: bgp_vpls200, ID: 200
 SIG-Protocol: BGP
  Route-Distinguisher :100:200
  Route-Target :100:200
  VE-ID :500
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Enabled, Direction: Transmit, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: eth1.200
 Subinterface Match Criteria(s) :
  dot1q 200
 Mesh Peers:
```

```
   1.1.1.1 (Up)



#ping mpls bgp_vpls 200 peer 1.1.1.1/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

 !
 !
 !
 !
 !

Success Rate is 100.00 percent (5/5)
```

P1

```
==
P1#clear interface counters

P1#show interface counters rate mbps
+--------------------+---------------+--------------+---------------+--------------+
|     Interface      |    Rx mbps    |    Rx pps    |    Tx mbps    |    Tx pps    |
+--------------------+---------------+--------------+---------------+--------------+
 Po10                 1549.80         1265260        1034.60         844649
 Po30                 0.01            8              0.00            8
 xe4                  1034.60         844647         1549.80         1265257
 xe10                 0.00            0              0.00            0
 xe11                 0.00            0              0.00            0
 xe12                 943.60          773213         474.05          384785
 xe13                 0.00            4              0.00            4
 xe16                 606.20          492047         560.54          459865
 xe17                 0.00            0              0.00            0
 xe19                 0.00            4              0.00            4
P1#

P4
==
P4#clear interface counters
```

```
P4#show interface counters rate mbps
+-------------------+---------------+--------------+---------------+--------------+
|     Interface     |    Rx mbps    |    Rx pps    |    Tx mbps    |    Tx pps    |
+-------------------+---------------+--------------+---------------+--------------+
 Po20                1549.80         1265260        1034.60         844649
 Po40                0.01            8              0.00            8
 xe4                 1034.60         844647         1549.80         1265257
 xe10                0.00            0              0.00            0
 xe11                0.00            0              0.00            0
 xe12                943.60          773213         474.05          384785
 xe13                0.00            4              0.00            4
 xe16                606.20          492047         560.54          459865
 xe17                0.00            0              0.00            0
 xe19                0.00            4              0.00            4
P1#
```

Configuration for VPWS with FAT

PE-1

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 1.1.1.1/32 secondary`	Configure IP address for the loopback interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 1.1.1.1`	Configure Router-id
`(config-router)#commit`	Commit the transaction.
`(config-router)#exit`	Exit from router mode
`(config-router)#targeted-peer ipv4 6.6.6.6`	Configuring targeted LDP sessions to PE-2
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted-peer mode
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#interface eth2`	Enter interface mode
`(config-if)#ip address 10.1.1.1/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

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`(config-router)#ospf router-id 1.1.1.1`	Configure ospf Router-id
`(config-router)#network 10.1.1.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 1.1.1.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#mpls l2-circuit VPWS4 400 3.3.3.3`	Configure the VC for PE-2
`PE1(config-vpls)#flow-label both`	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
`(config-pseudowire)#commit`	Commit the configuration
`(config-pseudowire)#exit`	Exit from pseudowire configuration mode
`(config-if)#interface eth2.300 switchport`	Enter sub interface mode
`(config-if)#encapsulation dot1q 300`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpws`	Access VPWS under sub interface
`(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary`	Associating the VPWS Instance to the attachment circuit interface.
`(config-acc-if-vpws)#commit`	Commit the configuration
`(config-acc-if-vpws)#end`	Return to privilege mode

P1

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 2.2.2.2/32 secondary`	Configure IP address for the loopback interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 2.2.2.2`	Configure Router-id
`(config-router)#commit`	Commit the transaction.
`(config-router)#exit`	Exit from router mode
`(config)#interface eth1`	Enter interface mode
`(config-if)#ip address 10.1.1.2/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#interface po10`	Enter interface mode
`(config-if)#ip address 10.1.2.1/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode

(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po30	Enter interface mode
(config-if)#ip address 10.1.3.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 30 mode active	Moving interface to Dynamic LAG 30
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 3.3.3.3	Configure Router-id
(config-router)#commit	Commit the transaction.

(config-router)#exit	Exit from router mode
(config)#interface po10	Enter interface mode
(config-if)#ip address 10.1.2.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth1	Enter the Interface mode for eth1
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 10 mode active	Moving interface to Dynamic LAG 10
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.2/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure ospf Router-id
(config-router)#network 10.1.2.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.1.4.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface

`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 4.4.4.4`	Configure Router-id
`(config-router)#commit`	Commit the transaction.
`(config-router)#exit`	Exit from router mode
`(config)#interface po30`	Enter interface mode
`(config-if)#ip address 10.1.3.2/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config-if)#interface eth1`	Enter the Interface mode for eth1
`(config-if)#channel-group 30 mode active`	Moving interface to Dynamic LAG 30
`(config-if)#interface eth2`	Enter the Interface mode for eth2
`(config-if)#channel-group 30 mode active`	Moving interface to Dynamic LAG 30
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit the transaction.
`(config)#interface po40`	Enter interface mode
`(config-if)#ip address 10.1.5.2/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config-if)#interface eth3`	Enter the Interface mode for eth3
`(config-if)#channel-group 40 mode active`	Moving interface to Dynamic LAG 40
`(config-if)#interface eth4`	Enter the Interface mode for eth4
`(config-if)#channel-group 40 mode active`	Moving interface to Dynamic LAG 40
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit the transaction.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#ospf router-id 4.4.4.4`	Configure ospf Router-id
`(config-router)#network 10.1.3.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 10.1.5.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 4.4.4.4/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.
`(config-router)#exit`	Exit from router mode

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P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 5.5.5.5	Configure Router-id
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#interface eth1	Enter interface mode
(config-if)#ip address 10.1.6.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po20	Enter interface mode
(config-if)#ip address 10.1.4.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth2	Enter the Interface mode for eth2
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#interface eth3	Enter the Interface mode for eth3
(config-if)#channel-group 20 mode active	Moving interface to Dynamic LAG 20
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#interface po40	Enter interface mode
(config-if)#ip address 10.1.5.1/24	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface eth4	Enter the Interface mode for eth4
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#interface eth5	Enter the Interface mode for eth5
(config-if)#channel-group 40 mode active	Moving interface to Dynamic LAG 40
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#ospf router-id 5.5.5.5`	Configure ospf Router-id
`(config-router)#network 10.1.4.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 10.1.5.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 10.1.6.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 5.5.5.5/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.
`(config-router)#exit`	Exit from router mode

PE-2

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 6.6.6.6/32 secondary`	Configure IP address for the loopback interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 6.6.6.6`	Configure Router-id
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configuring targeted LDP sessions to PE-2
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted-peer mode
`(config-router)#transport-address ipv4 6.6.6.6`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#interface eth2`	Enter interface mode
`(config-if)#ip address 10.1.6.2/24`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#ospf router-id 6.6.6.6`	Configure ospf Router-id
`(config-router)#network 10.1.6.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 6.6.6.6/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the configuration

`(config-router)#exit`	Exit from router mode
`(config)#mpls l2-circuit VPWS4 400 1.1.1.1`	Configure the VC for PE-2
`PE1(config-vpls)#flow-label both`	Configure flow label based on requirement (we have three options both, transit and receive) with dynamic and static.
`(config-pseudowire)#commit`	Commit the configuration
`(config-pseudowire)#exit`	Exit from pseudowire configuration mode
`(config-if)#interface eth2.300 switchport`	Enter sub interface mode
`(config-if)#encapsulation dot1q 300`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpws`	Access VPWS under sub interface
`(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary`	Associating the VPWS Instance to the attachment circuit interface.
`(config-acc-if-vpws)#commit`	Commit the configuration
`(config-acc-if-vpws)#end`	Return to privilege mode

Validation

PE1

```
---
PE1#show mpls vc-table
(m) - Service mapped over multipath transport

VC-ID      Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label
Nexthop         Status
400         N/A      N/A            xe18.300      xe4            24967      24961
6.6.6.6     Active

PE1#
PE1#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: VPWS4, id: 300  PW-INDEX: 4 service-tpid: dot1.q
 Endpoint: 6.6.6.6
 Control Word: 0
 Flow Label Status: Enabled, Direction: Both, Static: Yes
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe18.200
 Subinterface Match Criteria(s) :
  dot1q 300
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
```

PE2

```
===
PE2#show mpls vc-table
(m) - Service mapped over multipath transport

VC-ID      Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label
Nexthop         Status
```

```
400         N/A      N/A           xe4.300      xe18          24967      24961
1.1.1.1     Active

PE2#
PE2#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: VPWS4, id: 300  PW-INDEX: 4 service-tpid: dot1.q
 Endpoint: 1.1.1.1
 Control Word: 0
 Flow Label Status: Enabled, Direction: Both, Static: Yes
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe4.200
 Subinterface Match Criteria(s) :
  dot1q 200
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
```

P1

```
==
P1#clear interface counters

P1#show interface counters rate mbps
+-------------------+--------------+-------------+--------------+-------------+
|     Interface     |    Rx mbps   |    Rx pps   |    Tx mbps   |    Tx pps   |
+-------------------+--------------+-------------+--------------+-------------+
 Po10                1549.80        1265260       1034.60        844649
 Po30                0.01           8             0.00           8
 xe4                 1034.60        844647        1549.80        1265257
 xe10                0.00           0             0.00           0
 xe11                0.00           0             0.00           0
 xe12                943.60         773213        474.05         384785
 xe13                0.00           4             0.00           4
 xe16                606.20         492047        560.54         459865
 xe17                0.00           0             0.00           0
 xe19                0.00           4             0.00           4
P1#
```

P4

```
==
P4#clear interface counters

P4#show interface counters rate mbps
+-------------------+--------------+-------------+--------------+-------------+
|     Interface     |    Rx mbps   |    Rx pps   |    Tx mbps   |    Tx pps   |
+-------------------+--------------+-------------+--------------+-------------+
 Po20                1549.80        1265260       1034.60        844649
 Po40                0.01           8             0.00           8
 xe4                 1034.60        844647        1549.80        1265257
 xe10                0.00           0             0.00           0
```

```
 xe11                    0.00           0              0.00           0
 xe12                    943.60         773213         474.05         384785
 xe13                    0.00           4              0.00           4
 xe16                    606.20         492047         560.54         459865
 xe17                    0.00           0              0.00           0
 xe19                    0.00           4              0.00           4
P1#
```

CHAPTER 2 L2VPN Sub Interface Configuration

L2VPN is a layer 2 service where different locations (customer sites) of an enterprise interconnect to form a big LAN segment. All the locations can exchange layer 2 data with each other via this Virtual LAN in a private and secured way.

The MPLS Core-based L2VPN model has two broad divisions:

- Virtual Private Wire Service (VPWS)
- Virtual Private LAN Service (VPLS)

Virtual Private Wire Service or VPWS is a Point-to-Point (P2P) service implementation of L2VPN. It provides layer 2 data flow of the same or different types (FR, ATM, etc.) of L2 services over the MPLS core attaching the two customer sites.

Virtual Private LAN Service (VPLS) is a Point-to-Multipoint (P2MP) and Multipoint-to-Multipoint (MP2MP) L2VPN service. VPLS is designed for applications that require multipoint access across geographically distributed locations. Using VPLS, several customer sites (or distributed Ethernet LANs) can be interconnected to work as a single bridged domain over the MPLS network. In simple terms, VPLS uses the Layer 2 architecture to create multipoint VPNs that connect several sites over a Wide Area Network (WAN) or Metropolitan Area Network (MAN). The different customer sites are connected via the Service Provider's MPLS core network.

Topology

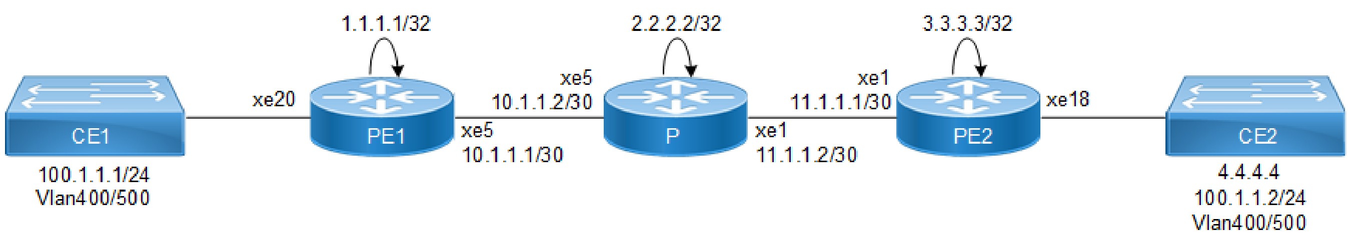

Figure 2-13: Link detection debounce timer topology

VPLS Configuration

All configuration commands in the table below should be followed for each Router.

PE1

`#configure terminal`	Enter Configure mode.
`(config)#router isis 1`	Create an IS-IS routing instance for area 49
`(config-router)#net 49.3600.3600.0001.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 1.1.1.1/32 secondary`	Configure IP address for the loopback interface
`(config-if)#ip router isis 1`	Enable IS-IS routing on an interface for area 49
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode

(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.1/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 1.1.1.1	Configure Router-id
(config-router)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls vpls vpls100 100	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#vpls-peer 3.3.3.3	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface xe20.100 switchport	Enter sub interface mode
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vpls100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#commit	Commit the configuration
(config-acc-if-vpls)#end	Return to privilege mode

P

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit router mode
(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.2/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode
(config-if)# ip address 11.1.1.2/30	Configure IP address on interface
(config-if)# label-switching	Enable label switching capability on the interface
(config-if)# ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)# enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

PE2

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)# router-id 3.3.3.3	Configure Router-id
(config-router)# targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-1
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)# transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration

`(config-router)#exit`	Exit from router mode
`(config)#interface xe1`	Enter interface mode
`(config-if)#ip address 11.1.1.1/30`	Configure IP address on interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#ip router isis 1`	Enable IS-IS routing on an interface for area 49
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configurations
`(config-if)#exit`	Exit interface mode
`(config)#mpls vpls vpls100 100`	Configuring VPLS instance with name and VPLS ID
`(config-vpls)#signaling ldp`	Enabling LDP signaling for the VPLS instance
`(config-vpls-sig)#vpls-peer 1.1.1.1`	Configuring VPLS mesh peers
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode
`(config-vpls)#exit-vpls`	Exit from VPLS mode
`(config)#interface xe18.100 switchport`	Enter sub interface mode
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if)#encapsulation dot1q 100`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpls`	Access VPLS under sub interface
`(config-acc-if-vpls)#mpls-vpls vpls100`	Associating the VPLS Instance to the attachment circuit interface.
`(config-acc-if-vpls)#commit`	Commit the configuration
`(config-acc-if-vpls)#end`	Return to privilege mode

Validation

PE1

```
#ping mpls vpls 100 peer 3.3.3.3/32
Sending 5 MPLS Echos to VPLS Id : 100, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

  !
  !
  !
  !
  !
```

```
Success Rate is 100.00 percent (5/5)

#show mpls vpls mesh
(m) - Service mapped over multipath transport

VPLS-ID  Peer Addr Tunnel-Label  In-Label  Network-Intf  Out-Label  Lkps/St  PW-INDEX
SIG-Protocol  Status
100     3.3.3.3  24320        24320    xe5         24320     2/Up    1       LDP
Active

#show mpls vpls detail
Virtual Private LAN Service Instance: vpls100, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe20.100
 Subinterface Match Criteria(s) :
  dot1q 100
 Mesh Peers:
   3.3.3.3 (Up)
```

VPWS Configuration

All configuration commands in the table below should be followed for each Router.

PE1

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config -if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.1/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface

(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 1.1.1.1	Configure Router-id
(config-router)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#mpls l2-circuit VPWS4 400 3.3.3.3	Configure the VC for PE-2
(config-pseudowire)#commit	Commit the configuration
(config-pseudowire)#exit	Exit from pseudowire configuration mode
(config)#interface xe20.400 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 400	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#commit	Commit the configuration
(config-acc-if-vpws)#end	Return to privilege mode

P

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 2.2.2.2	Configure Router-id
(config-router)# transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit router mode

(config)#interface xe5	Enter interface mode
(config-if)#ip address 10.1.1.2/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe1	Enter interface mode
(config-if)# ip address 11.1.1.2/30	Configure IP address on interface
(config-if)# label-switching	Enable label switching capability on the interface
(config-if)# ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)# enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

PE2

#configure terminal	Enter Configure mode.
(config)#router isis 1	Create an IS-IS routing instance for area 49
(config-router)#net 49.3600.3600.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface lo	Enter interface mode
(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)# router-id 3.3.3.3	Configure Router-id
(config-router)# targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE-1
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)# transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface xe1	Enter interface mode
(config-if)#ip address 11.1.1.1/30	Configure IP address on interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#ip router isis 1	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enabling LDP on the interface

`(config-if)#commit`	Commit the configurations
`(config-if)#exit`	Exit interface mode
`(config)#mpls l2-circuit VPWS4 400 1.1.1.1`	Configure the VC for PE-1
`(config-pseudowire)#commit`	Commit the configuration
`(config-pseudowire)#exit`	Exit from pseudowire configuration mode
`(config)#interface xe18.400 switchport`	Enter sub interface mode
`(config-if)#encapsulation dot1q 400`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpws`	Access VPWS under sub interface
`(config-acc-if-vpws)#mpls-l2-circuit VPWS4 primary`	Associating the VPWS Instance to the attachment circuit interface.
`(config-acc-if-vpws)#commit`	Commit the configuration
`(config-acc-if-vpws)#end`	Return to privilege mode
`(config)#mpls l2-circuit VPWS4 400 1.1.1.1`	Configure the VC for PE-1
`(config-pseudowire)#commit`	Commit the configuration

Validation

PE1

```
#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: VPWS4, id: 400  PW-INDEX: 4 Endpoint: 3.3.3.3
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe20.400
 Subinterface Match Criteria(s) :
  dot1q 400
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active


#show ldp mpls-l2-circuit
Transport     Client     VC     VC             Local       Remote      Destination
VC ID         Binding    State  Type           VC Label    VC Label    Address
400           xe20.400   UP     Ethernet VLAN  24322       24322       3.3.3.3

#ping mpls l2-circuit 400
Sending 5 MPLS Echos to VC Id : 400, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
```

```
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

 !
 !
 !
 !
 !

Success Rate is 100.00 percent (5/5)
```

CHAPTER 3 Virtual Private LAN Service Configuration

This chapter contains configurations for Virtual Private LAN Service (VPLS).

VPLS Raw Mode

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE1, PE2, and PE3 in raw mode.

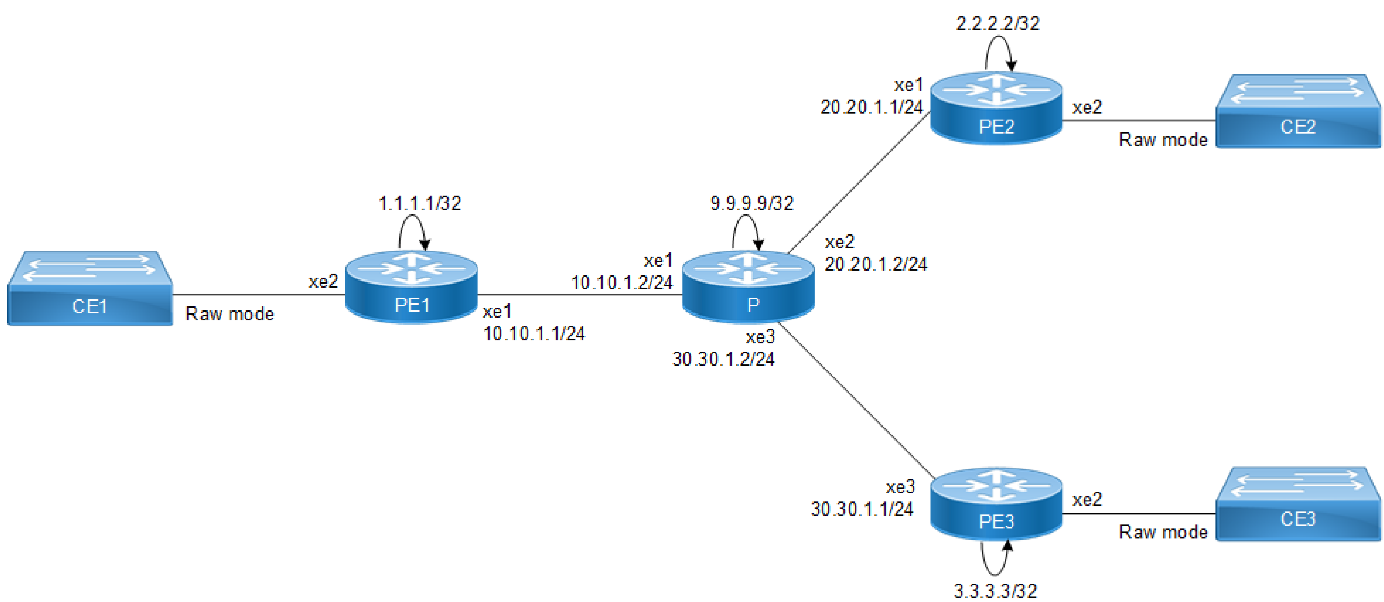

Figure 3-14: VPLS Mesh Peers Raw Mode

Configuration

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the Interface (xe1) to be configured.
`(config-if)#ip address 10.10.1.1/24`	Configure IP address for the interface.
`(config-if)#no shutdown`	Administratively brining up the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the routing process ID (100).
`(config-router)#network 10.10.1.0/24 area 0` `(config-router)#network 1.1.1.1/32 area 0`	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
`(config-router)#exit`	Exit router mode.

`(config)#router ldp`	Enter router mode for LDP.
`(config-router)# router-id 1.1.1.1`	Configure the router-id
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
`(config-router)#targeted-peer ipv4 2.2.2.2`	Configuring targeted LDP sessions to PE2
`(config-router-targeted-peer)#exit`	Exit config-router-targeted-peer mode
`(config-router)#targeted-peer ipv4 3.3.3.3`	Enter targeted-peer-mode and PE3
`(config-router-targeted-peer)#exit`	Exit config-router-targeted-peer mode
`(config-router)#exit`	Exit router configuration mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching capability on the interface.
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls vpls VPLS1 100`	Configuring VPLS instance with name and VPLS ID.
`(config-vpls)#signaling ldp`	Enabling LDP signaling for the VPLS instance.
`(config-vpls-sig)#vpls-peer 2.2.2.2` `(config-vpls-sig)#vpls-peer 3.3.3.3`	Configuring VPLS mesh peers.
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode.
`(config-vpls)#exit`	Exit from VPLS Mode.
`(config)#service-template st1`	Template configuration
`(config-svc)#exit`	Exit service template mode
`(config)#interface xe2`	Specify the attachment circuit interface.
`(config-if)#switchport`	Configuring the attachment circuit interface as Layer-2.
`(config-if)mpls-vpls VPLS1 service-template st1`	Associating the VPLS Instance to the attachment circuit interface.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)exit`	Exit interface mode.
`(config)#commit`	Commit the transaction.
`#copy running-config startup-config`	Save the configuration.

P

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 9.9.9.9/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the interface to be configured.
`(config-if)#ip address 10.10.1.2/24`	Configure IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 20.20.1.2/24`	Configure IP address for the interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 30.30.1.2/24	Configure IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 10.10.1.0/24 area 0 (config-router)#network 20.20.1.0/24 area 0 (config-router)#network 30.30.1.0/24 area 0 (config-router)#network 9.9.9.9/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 9.9.9.9	Confirm the router-id
(config-router)#transport-address ipv4 9.9.9.9	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(congig-if)#exit	Exit interface configuration mode.
(config)#interface xe2	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(congig-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(congig-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 20.20.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#exit	Exit interface mode.

`(config)#router ospf 100`	Configure the routing process and specify the routing process ID(100).
`(config-router)#network 20.20.1.0/24 area 0` `(config-router)#network 2.2.2.2/32 area 0`	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
`(config-router)#exit`	Exit router mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 2.2.2.2`	Confirm the router-id
`(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configuring targeted LDP sessions to PE2.
`(config-router-targeted-peer)#exit`	Exit targeted-peer-mode
`(config-router)#targeted-peer ipv4 3.3.3.3`	Configuring targeted LDP sessions to PE3
`(config-router-targeted-peer)#exit`	Exit targeted-peer-mode
`(config-router)#exit`	Exit router configuration mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching capability on the interface.
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls vpls VPLS1 100`	Configuring VPLS instance with name and VPLS ID.
`(config-vpls)#signaling ldp`	Enabling LDP signaling for the VPLS instance.
`(config-vpls-sig)#vpls-peer 1.1.1.1` `(config-vpls-sig)#vpls-peer 3.3.3.3`	Configuring VPLS mesh peers.
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode.
`(config-vpls)#exit`	Exit from VPLS Mode.
`(config)#service-template st1`	Template configuration.
`(config-svc)#exit`	Exit service template mode.
`(config)#interface xe2`	Specify the attachment circuit interface.
`(config-if)#switchport`	Configuring the attachment circuit interface as Layer-2.
`(config-if)mpls-vpls VPLS1 service-template st1`	Associating the VPLS Instance to the attachment circuit interface.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)exit`	Exit interface mode.
`(config)#commit`	Commit the transaction.
`#copy running-config startup-config`	Save the configuration.

PE3

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 3.3.3.3/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the Interface (xe1) to be configured.

`(config-if)#ip address 30.30.1.1/24`	Configure IP address for the interface.
`(config-if)#no shutdown`	Administratively brining up the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the routing process ID(100).
`(config-router)#network 30.30.1.0/24 area 0` `(config-router)#network 3.3.3.3/32 area 0`	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
`(config-router)#exit`	Exit router mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 3.3.3.3`	Confirm the router-id
`(config-router)#transport-address ipv4 3.3.3.3`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run.
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configuring targeted LDP sessions to PE2
`(config-router-targeted-peer)#exit`	Exit targeted-peer-mode
`(config-router)#targeted-peer ipv4 2.2.2.2`	Configuring targeted LDP sessions to PE3
`(config-router-targeted-peer)#exit`	Exit targeted-peer-mode
`(config-router)#exit`	Exit router configuration mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching capability on the interface.
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls vpls VPLS1 100`	Configuring VPLS instance with name and VPLS ID.
`(config-vpls)#signaling ldp`	Enabling LDP signaling for the VPLS instance.
`(config-vpls-sig)#vpls-peer 1.1.1.1` `(config-vpls-sig)#vpls-peer 2.2.2.2`	Configuring VPLS mesh peers.
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode.
`(config-vpls)#exit`	Exit from VPLS Mode.
`(config)#service-template st1`	Template configuration.
`(config-svc)#exit`	Exit service template mode.
`(config)#interface xe2`	Specify the attachment circuit interface.
`(config-if)#switchport`	Configuring the attachment circuit interface as Layer-2.
`(config-if)mpls-vpls VPLS1 service-template st1`	Associating the VPLS Instance to the attachment circuit interface.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)exit`	Exit interface mode.
`(config)#commit`	Commit the transaction.
`#copy running-config startup-config`	Save the configuration.

Validation

PE1

Verify VPLS Session

```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe2
 Service-template : st1
  Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Up)
   3.3.3.3 (Up)
PE1#
```

Verify VPLS Mesh Peer

```
PE1#sh mpls vpls mesh

VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St   PW-INDEX SIG-Protocol  Status
100        2.2.2.2           24325         24321      xe1            24321      2/Up      1        LDP           Active
100        3.3.3.3           24322         24320      xe1            24321      2/Up      2        LDP           Active

PE1#show ldp session
Peer IP Address  IF Name  My Role  State       KeepAlive UpTime
2.2.2.2          xe1      Passive  OPERATIONAL  30       00:32:21
3.3.3.3          xe1      Passive  OPERATIONAL  30       00:20:50
9.9.9.9          xe1      Passive  OPERATIONAL  30       00:34:18

PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID   Pri  State          Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/Backup   00:00:35   10.10.1.2    xe1       0

P#show ldp session
Peer IP Address  IF Name  My Role  State        KeepAlive UpTime
1.1.1.1          xe1      Active   OPERATIONAL  30        00:40:04
2.2.2.2          xe2      Active   OPERATIONAL  30        00:38:22
3.3.3.3          xe3      Active   OPERATIONAL  30        00:25:57
```

```
P#show ip ospf neighbor
Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface  Instance ID
10.12.49.142   1  Full/DR    00:00:34  10.10.1.1   xe1       0
10.12.49.144   1  Full/Backup   00:00:29  20.20.1.1   xe2  0
10.12.49.146   1  Full/Backup   00:00:36  30.30.1.1   xe3  0
PE2#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
SIG-Protocol: LDP Attachment-Circuit :UP
Learning: Enabled Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No Group ID: 0, VPLS Type: 
Ethernet,
Configured MTU: 1500
Description: none service-tpid: dot1.q Operating mode: Raw Configured interfaces:
 Interface: xe2 Service-template : st1
Match criteria : Accept all
Mesh Peers:
 1.1.1.1 (Up)
 3.3.3.3 (Up)

PE2#show mpls vpls mesh
VPLS-ID  Peer Addr  Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX SIG-Protocol Status
100       1.1.1.1   25601        26240      xe1          26240     2/Up      1       LDP          Active
100       3.3.3.3   25603        26241      xe1          26241     2/Up      2       LDP          Active

PE2#show ldp session
Peer IP Address     IF Name  My Role  State        KeepAlive UpTime
1.1.1.1             xe1      Active   OPERATIONAL  30        00:41:59
3.3.3.3             xe1      Passive  OPERATIONAL  30        00:30:15
9.9.9.9             xe1      Passive  OPERATIONAL  30        00:42:14

PE2#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface      Instance ID
10.12.49.145   1  Full/DR    00:00:35  20.20.1.2   xe1           0

PE3#show ldp session
Peer IP Address IF Name  My Role  State   KeepAlive UpTime
1.1.1.1         xe1   Active  OPERATIONAL  30  00:44:25
2.2.2.2         xe1   Active  OPERATIONAL  30  00:44:13
9.9.9.9         xe1   Passive  OPERATIONAL  30  00:43:47

PE3#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/DR    00:00:33  30.30.1.2   xe1       0

PE3#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
```

```
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
 Interface: xe2
Service-template : st1
Match criteria : Accept all

Mesh Peers:
 1.1.1.1 (Up)
 2.2.2.2 (Up)
```

```
PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VPLS-ID  Peer Addr    Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX  SIG-Protocol Status
100       1.1.1.1     25602        26240     xe1           26241        2/Up      ]     LDP          Active
100       2.2.2.2     25603        26241     xe1           26241        2/Up      2     LDP          Active
```

VPLS Tagged Mode

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE1, PE2, and PE3 in Tagged Mode. In the below example PE1 and PE2 uses VLAN 10 for binding the VPLS instance to the attachment circuit and PE3 used VLAN 20 where it shows that VLAN swapping is supported.

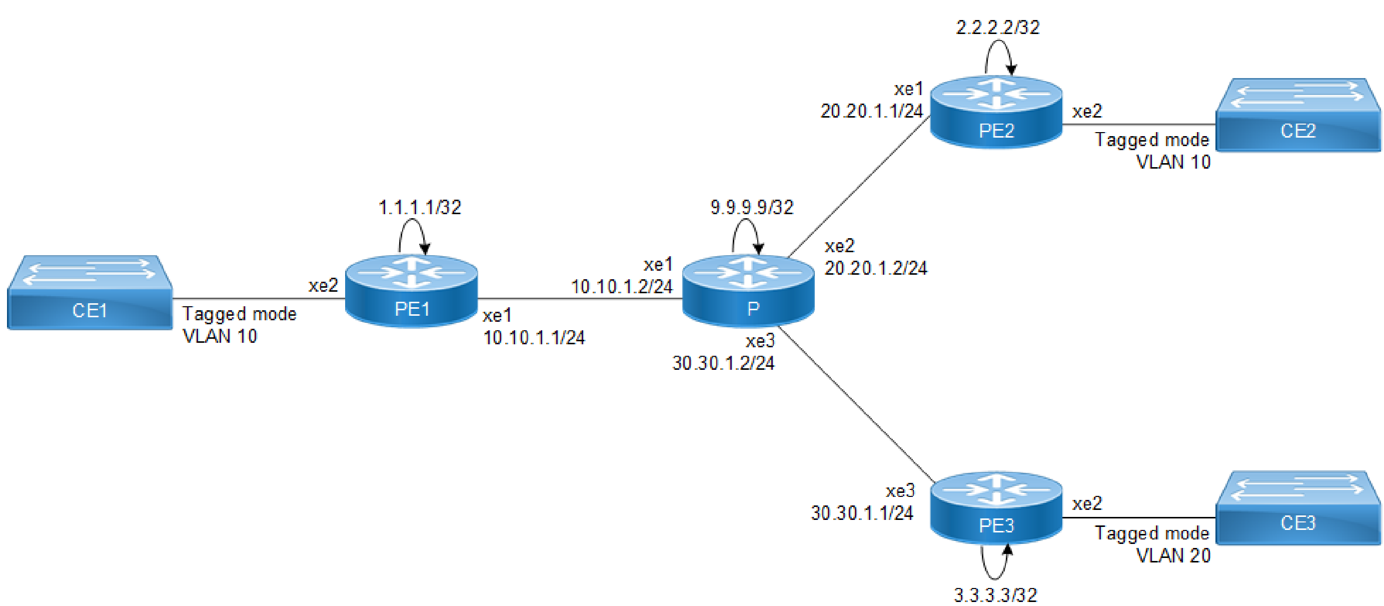

Figure 3-15: VPLS Mesh Peers Tagged Mode

Configuration

PE1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 10.10.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 10.10.1.0/24 area 0 (config-router)#network 1.1.1.1/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 2.2.2.2	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE3
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router)#exit	Exit router configuration mode
(config)#interface xe1	Enter interface mode
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-type vlan	Configuring VPLS type as VLAN mode.
(config-vpls-sig)#vpls-peer 2.2.2.2 (config-vpls-sig)#vpls-peer 3.3.3.3	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 2.2.2.2	Configure VPLS Peers
config-vpls-sig)#vpls-peer 3.3.3.3	Configure VPLS Peers
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode

(config-vpls)#exit	Exit VPLS mode
(config)#service-template st1	Template configuration.
(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode.
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls VPLS1 service-template st1	Associating the VPLS Instance to the attachment circuit interface to match service template st1.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

Service template with Multiple Match Support

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)#match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)#match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)#match untagged	Allow untagged traffic
(config-svc)#rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls v4 service-template template4	Associating the VPLS Instance to the attachment circuit interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 9.9.9.9/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface to be configured.
(config-if)#ip address 10.10.1.2/24	Configure IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.20.1.2/24	Configure IP address for the interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 30.30.1.2/24	Configure IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 10.1.1.0/24 area 0 (config-router)#network 20.20.1.0/24 area 0 (config-router)#network 30.30.1.0/24 area 0 (config-router)#network 9.9.9.9/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(congig-if)#exit	Exit interface configuration mode.
(config)#interface xe2	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(congig-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(congig-if)#exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 20.20.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 20.20.1.0/24 area 0 (config-router)#network 2.2.2.2/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.

(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#targeted-peer ipv4 3.3.3.3	Configuring targeted LDP sessions to PE3
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit targeted peer mode.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-type vlan	Configuring VPLS type as VLAN mode.
(config-vpls-sig)#vpls-peer 1.1.1.1 (config-vpls-sig)#vpls-peer 3.3.3.3	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 1.1.1.1	Configure VPLS Peers
config-vpls-sig)#vpls-peer 3.3.3.3	Configure VPLS Peers
(config-vpls-sig)#exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#service-template st1	Template configuration.
(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode.
(config)#service-template template4	Template configuration
(config-svc)#match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)#match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)#match untagged	Allow untagged traffic
(config-svc)#rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls VPLS1 service-template st1	Associating the VPLS Instance to the attachment circuit interface to match service template st1.
(config-if)mpls-vpls v4 service-template template4	Associating the VPLS Instance to the attachment circuit interface.

(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE3

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface (xe1) to be configured.
(config-if)#ip address 30.30.1.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#network 30.30.1.0/24 area 0 (config-router)#network 3.3.3.3/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 1.1.1.1	Configuring targeted LDP sessions to PE2
(config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router-targeted-peer)#targeted-peer ipv4 2.2.2.2	Configuring targeted LDP sessions to PE3
config-router-targeted-peer)#exit	Exit targeted peer mode
(config-router)#exit	Exit router configuration mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#enable-ldp ipv4	Enabling LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#mpls vpls VPLS1 100	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls-sig)#vpls-type vlan	Configuring VPLS type as VLAN mode.
(config-vpls-sig)#vpls-peer 1.1.1.1 (config-vpls-sig)#vpls-peer 2.2.2.2	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS

(config-vpls-sig)#vpls-peer 1.1.1.1	Configure VPLS Peers
(config-vpls-sig)#vpls-peer 2.2.2.2	Configure VPLS Peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#service-template st1	Template configuration.
(config-svc)#match outer-vlan 20	Match criteria under template configuration
(config-svc)#exit	Exit service template mode.
(config)#service-template template4	Template configuration
(config-svc)#match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)#match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)#match untagged	Allow untagged traffic
(config-svc)#rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)mpls-vpls v4 service-template st1	Associating the VPLS Instance to the attachment circuit interface to match service template st1.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

Validation

PE1

Verify VPLS Session:

```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 Configured interfaces:
  Interface: xe2
 Service-template : s1
  Match criteria : 10

 Mesh Peers:
   2.2.2.2 (Up)
```

```
   3.3.3.3 (Up)

Virtual Private LAN Service Instance: v4, ID: 28
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 Configured interfaces:
  Interface: xe2
 Service-template : template4
     Match criteria : 700
    1200/3200
    Untagged
    Action type : Push
    Action value : 300

 Mesh Peers:
   2.2.2.2 (Up)
   3.3.3.3 (Up)
PE1#
```

Verify VPLS Mesh Peer:

```
PE1#show mpls vpls mesh
VPLS-ID       Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-
Label  Lkps/St   PW-INDEX  SIG-Protocol   Status   Ecmp-Group100
100         2.2.2.2       24320         24322      xe2           24321      2/
Up      1         LDP           Active      N/A
100         3.3.3.3       24325         24321      xe2           24323      2/
Up      1         LDP           Active      N/A
28         2.2.2.2       24327         24324      xe2           24325      2/
Up      1         LDP           Active      N/A
28         3.3.3.3       24345         24325      xe2           24324      2/
Up      1         LDP           Active      N/A

PE1#show ldp session
Peer IP Address   IF Name  My Role  State        KeepAlive UpTime
2.2.2.2           xe1      Passive  OPERATIONAL  30        00:22:12
3.3.3.3           xe1      Passive  OPERATIONAL  30        00:17:27
9.9.9.9           xe1      Passive  OPERATIONAL  30        00:24:53

PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri State        Dead Time Address   Interface   Instance ID
9.9.9.9       1  Full/Backup  00:00:37  10.10.1.2  xe1        0

p#show ldp session
Peer IP Address   IF Name  My Role  State        KeepAlive UpTime
1.1.1.1           xe1      Active   OPERATIONAL  30        00:03:07
2.2.2.2           xe2      Active   OPERATIONAL  30        00:25:52
3.3.3.3           xe3      Active  OPERATIONAL   30        00:03:09

p#show ip ospf neighbor
```

```
Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID  Pri State      Dead Time  Address   Interface   Instance ID
1.1.1.1       1  Full/DR     00:00:30  10.10.1.1  xe1       0
2.2.2.2       1 Full/Backup  00:00:38  20.20.1.1  xe2       0
3.3.3.3       1 Full/Backup  00:00:37  30.30.1.1  xe3       0

PE2#show mpls vpls detail
Virtual Private LAN Service Instance: v4, ID: 28
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 Configured interfaces:
 Interface: xe2
 Service-template : template4
 Match criteria : 700,
 Untagged ,
 1200/3200
 Action type : Push
 Action value : 300

 Mesh Peers:
 1.1.1.1 (Up)
 3.3.3.3 (Up)

Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 Configured interfaces:
 Interface: xe2
 Service-template : st1
 Match criteria : 10

 Mesh Peers:
 1.1.1.1 (Up)
 3.3.3.3 (Up)
```

```
PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VPLS-ID  Peer Addr   Tunnel-Label In-Label Network-Intf Out-Label Lkps/St PW-INDEX SIG-Protocol Status
```

```
28       1.1.1.1     25601       26241     xe1        26240      2/Up   1        LDP         Active
28       3.3.3.3     25603       26242     xe1        27523      2/Up   2        LDP         Active
100      1.1.1.1     25601       26240     xe1        26241      2/Up   3        LDP         Active
100      3.3.3.3     25603       26243     xe1        27520      2/Up   4        LDP         Active

PE2#show ldp session
Peer IP Address   IF Name  My Role  State        KeepAlive   UpTime
1.1.1.1           xe1      Active   OPERATIONAL  30          00:35:15
3.3.3.3           xe1      Passive  OPERATIONAL  30          00:30:51
9.9.9.9           xe1      Passive  OPERATIONAL  30          00:00:59

PE2#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri State    Dead Time   Address   Interface   Instance ID
9.9.9.9      1   Full/DR   00:00:32   20.20.1.2  xe1        0

PE3#show mpls vpls detail
Virtual Private LAN Service Instance: v4, ID: 28
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 Configured interfaces:
 Interface: xe2
 Service-template : template4
 Match criteria : 700,
 Untagged ,
 1200/3200
 Action type : Push
 Action value : 300

 Mesh Peers:
 1.1.1.1 (Up)
 2.2.2.2 (Up)

Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
```

```
 service-tpid: dot1.q
 Operating mode: Tagged
Svlan Id: 0

 Svlan Tpid: 8100
Configured interfaces:
 Interface: xe2
 Service-template : st1
 Match criteria : 20

 Mesh Peers:
 1.1.1.1 (Up)
 2.2.2.2 (Up)

PE3#show ldp session
Peer IP Address   IF Name  My Role  State         KeepAlive   UpTime
9.9.9.9           xe1      Passive  OPERATIONAL   30          00:02:23
1.1.1.1           xe1      Active   OPERATIONAL   30          00:31:56
2.2.2.2           xe1      Active   OPERATIONAL   30          00:32:17

PE3#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri State    Dead Time Address   Interface   Instance ID
9.9.9.9       1 Full/DR   00:00:37  30.30.1.2  xe1        0
```

Validation for the Number of Configured VPLS Instances

This example below shows number of configured VPLS instances.

```
PE1#show mpls vpls count
--------------------------------
Total VPLS instances    : 2
Active VPLS instances   : 2
Inactive VPLS instances : 2
--------------------------------
```

The example below shows the Count of VPLS from LDP standpoint

```
PE1#show ldp vpls count
--------------------------------
Total VPLS instances    : 2
Active VPLS instances   : 2
Inactive VPLS instances : 0
--------------------------------
```

The example below shows the number of MAC addresses learned by VPLS.

```
PE1#show mpls vpls mac-address count
Total no of MAC addresses learnt :6
```

VPLS Split Horizon Group

In VPLS Hierarchy, multiple attachment circuits (AC) can be configured per few VPLS instances and AC-AC traffic blocking is not supported.Thus,when the PE router receives a broadcast, multicast, or unknown unicast packet on an AC.It sends the packet out on all other attachment circuits to all other CE devices participating in that VPLS instance.

To avoid this problem of a packet looping in the provider core, the PE devices enforce a "split-horizon" principle for the VPLS instances. That means the traffic will not flood if AC1 and AC2 are in same split horizon group.

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE-1, PE-2 with split horizon group. In the below example PE-1 and PE-2 uses split horizon groups where traffic can't be forwarded between the ACs if they are part of same access groups.But can send/receive from network ports.

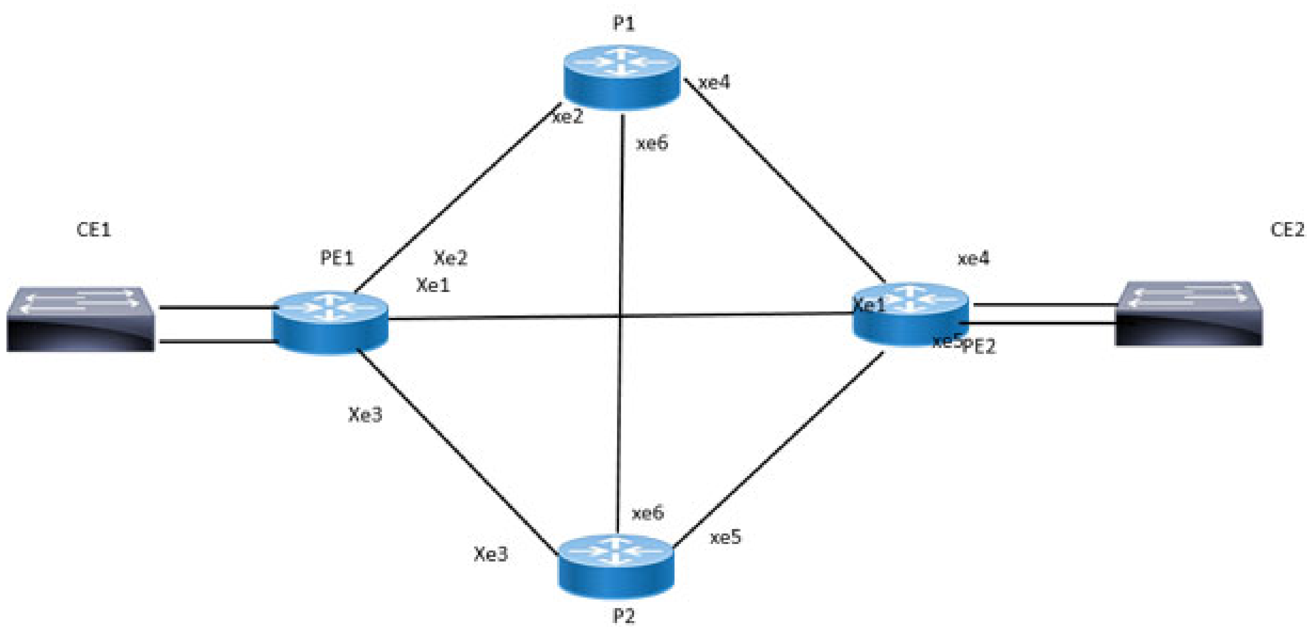

Figure 3-16: Figure 8-15: VPLS Mesh Peers split horizon

Configuration With Service Template

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 48.48.48.48/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe0`	Specify the Interface to be configured.
`(config-if)#ip address 40.40.40.1/24`	Configure IP address for the interface.
`(config-if)#no shutdown`	Administratively brining up the interface.
`(config-if)#label-switching`	Enable label switching on the interface
`(config-if)#mpls ldp-igp sync isis level-1-2`	Enable LDP IS-IS synchronization
`(config-if)#isis network point-to-point`	Configure the ISIS interface network type as point to point
`(config-if)#ip router isis ISIS-IGP`	Enable IS-IS routing on an interface

(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe19	Specify the Interface to be configured
(config-if)#ip address 57.57.57.6/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe20	Specify the Interface to be configured
(config-if)#ip address 52.52.52.5/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 48.48.48.48	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.
(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 45.45.45.45	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit	Exit config-router-targeted-peer mode
(config-router)#exit	Exit router configuration mode.
(config)#router bgp 65010	Define the routing process. The number 65010 specifies the AS number

(config-router)#bgp router-id 48.48.48.48	Assign a BGP router ID.
(config-router)#neighbor 45.45.45.45 remote-as 65010	Define the eBGP neighbor
(config-router)#neighbor 45.45.45.45 fall-over bfd multihop	Enabling BFD at BGP level for particular neighbor.
(config-router)#neighbor 45.45.45.45 update-source lo	Update the source for that particular neighbor as loopback interface
(config-router)#address-family ipv4 unicast	Enter into labeled-unicast address family
(config-router)#neighbor 45.45.45.45 activate	Activate the neighbor inside labeled-unicast address family
(config-router)#exit-address-family	Exit from address family IPv4 labeled unicast
(config-router)#address-family vpnv4 unicast	Enter into vpnv4 unicast address family
(config-router)#neighbor 45.45.45.45 activate	Activate the neighbor inside vpnv4 address family
(config-router)#exit-address-family	Exit from address family vpnv4
(config-router)#address-family ipv6 unicast	Enter into labeled-unicast address family
(config-router)#redistribute connected	Redistribute the connected routes.
(config-router)#exit-address-family	Exit from address family IPv6 labeled unicast
(config)#mpls vpls VPLS-PE1-PE2-600 600	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 45.45.45.45	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls VPLS-PE1-PE2-601 601	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 45.45.45.45	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls VPLS-PE1-PE2-602 602	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 45.45.45.45	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#service-template ST-VPLS-PE1-PE2-600	Template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template ST-VPLS-PE1-PE2-601	Template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template ST-VPLS-PE1-PE2-602	Template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe2	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.

(config-if)#mpls-vpls VPLS-PE1-PE2-600 service-template ST-VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-601 service-template ST-VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-602 service-template ST-VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config)#interface xe23	Specify the attachment circuit interface.
(config-if)#switchport	Configuring the attachment circuit interface as Layer-2.
(config-if)#mpls-vpls VPLS-PE1-PE2-600 service-template ST-VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-601 service-template ST-VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls VPLS-PE1-PE2-602 service-template ST-VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#split-horizon group access1	Configuring split horizon group
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)exit	Exit interface mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

P1

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 18.18.18.18/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface ge6	Specify the interface to be configured.
(config-if)#ip address 60.60.60.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enabling label switching capability on router
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface

(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the Interface to be configured
(config-if)#ip address 60.60.60.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Enable LDP IS-IS synchronization
(config-if)#ip router isis ISIS-IGP	Configure the ISIS interface network type as point to point
(config-if)#enable-ldp ipv4	Enable IS-IS routing on an interface
(config-if)#exit	Enable IPv4 LDP configuration on interface
(config)#interface xe3	Exit interface mode.
(config-if)#ip address 80.80.80.1/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 18.18.18.18	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.
(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

PE2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 45.45.45.45/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface to be configured.
(config-if)#ip address 60.60.60.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe4	Specify the Interface to be configured.
(config-if)#ip address 70.70.70.1/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe8	Specify the Interface to be configured.
(config-if)#ip address 57.57.57.7/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively brining up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 48.48.48.48	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.

(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config)#router ldp	Enter router mode for LDP.
(config-router)#targeted-peer ipv4 48.48.48.48	Configuring targeted LDP sessions to PE-2
(config-router-targeted-peer)#exit	Exit config-router-targeted-peer mode
(config-router)#exit	Exit router configuration mode.
(config)#router bgp 65010	Define the routing process. The number 65010 specifies the AS number
(config-router)#bgp router-id 45.45.45.45	Assign a BGP router ID.
(config-router)#neighbor 48.48.48.48 remote-as 65010	Define the eBGP neighbor
(config-router)#neighbor 48.48.48.48 fall-over bfd multihop	Enabling BFD at BGP level for particular neighbor.
(config-router)#neighbor 48.48.48.48 update-source lo	Update the source for that particular neighbor as loopback interface
(config-router)#address-family ipv4 unicast	Enter into labeled-unicast address family
(config-router)#neighbor 48.48.48.48 activate	Activate the neighbor inside labeled-unicast address family
(config-router)#exit-address-family	Exit from address family IPv4 labeled unicast
(config-router)#address-family vpnv4 unicast	Enter into vpnv4 unicast address family
(config-router)#neighbor 48.48.48.48 activate	Activate the neighbor inside vpnv4 address family
(config-router)#exit-address-family	Exit from address family vpnv4
(config-router)#address-family ipv6 unicast	Enter into labeled-unicast address family
(config-router)#redistribute connected	Redistribute the connected routes.
(config-router)#exit-address-family	Exit from address family IPv6 labeled unicast
(config)#mpls vpls VPLS-PE1-PE2-600 600	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 48.48.48.48	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#mpls vpls VPLS-PE1-PE2-601 601	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 48.48.48.48	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.

(config)#mpls vpls VPLS-PE1-PE2-602 602	Configuring VPLS instance with name and VPLS ID.
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance.
(config-vpls)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 48.48.48.48	Configuring VPLS mesh peers.
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode.
(config-vpls)#exit	Exit from VPLS Mode.
(config)#interface xe2.600 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 600	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe2.601 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 601	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe2.602 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 602	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
config-if-vpls)#mpls-vpls VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe23.600 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 600	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-600	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe23.601 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 601	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.

(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-601	Associating the VPLS Instance to the attachment circuit interface.
(config)#interface xe23.602 switchport	Creates a L2 sub-interface as xe2.600.
(config-if)#encapsulation dot1q 602	Configuring the attachment circuit interface as Layer-2.
(config-if)#rewrite push 0x8100 4050	Configure rewrite push.
(config-if)#split-horizon group access1	Configuring split horizon group.
(config-if-vpls)#load-interval 30	Configure load period in multiple of 30 seconds
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-if-vpls)#mpls-vpls VPLS-PE1-PE2-602	Associating the VPLS Instance to the attachment circuit interface.
(config-if)#commit	Commit the candidate configuration to the running configuration.
(config-if)#exit	Exit interface mode
#copy running-config startup-config	Save the configuration.

P2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 46.46.46.46/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface to be configured.
(config-if)#ip address 80.80.80.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 70.70.70.2/24	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#ip address 40.40.40.2/24	Specify the interface to be configured.
(config-if)#label-switching	Enable label switching on the interface

(config-if)#mpls ldp-igp sync isis level-1-2	Enable LDP IS-IS synchronization
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface for area 49
(config-if)#enable-ldp ipv4	Enable IPv4 LDP configuration on interface.
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config)#is-type level-1	Configure instance as level-2-only routing.
(config)#metric-style wide	Configure the new style of metric type as wide.
(config)#mpls traffic-eng router-id 46.46.46.46	Configure MPLS-TE unique router-id TLV.
(config)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config)#capability cspf	Enable CSPF feature for ISIS instance.
(config)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config)#fast-reroute ti-lfa level-1 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L1 IPv4 prefixes learned
(config)#fast-reroute ti-lfa level-2 proto ipv4	Configure LFA-FRR to calculate the available backup path for all L2 IPv4 prefixes learned
(config)#bfd all-interfaces	Enable BFD for all neighbors.
(config)#net 49.0000.0000.0004.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.
#copy running-config startup-config	Save the configuration.

VPLS - Per-Peer VPLS-type Signaling

Overview

Virtual Private LAN Service (VPLS) LDP signaling is a mechanism used to establish and manage pseudowires (PWs) in a VPLS network. VPLS allows geographically dispersed sites to share a common Ethernet broadcast domain, enabling any-to-any communication between the sites as if they were all connected to the same local area network (LAN).

VPLS LDP signaling occurs when each PE has discovered the endpoints of the VPLS instance. PWs are established over MPLS tunnels between VPN sites to transparently transmit Layer 2 packets. With the ability to configure the VPLS type per peer, and with the VPLS type configured being forwarded to LDP only when there is a change in the VPLS type at the VPLS instance or per peer level, signaling behavior is more efficient. Previously, the VPLS type at the VPLS instance was significant across all PEs involved in the VPLS instance.

If there is a change in the VPLS type at the VPLS instance or per peer level, NSM will update LDP, triggering LDP signaling. If there is no change, there is no need for re-signaling, and the VPLS session remains in the same state. The VPLS type configured on PEs at both ends of a pseudowire must match; otherwise, negotiation is required, and the VPLS session will be inactive until resolved.

Feature Characteristics

Provide the ability to configure the VPLS type on a per-peer basis, in addition to the VPLS type set across all PEs in the VPLS instance. The VPLS type configured on PEs at both ends of a pseudowire must match; otherwise, negotiation should occur. The per-peer VPLS type should take priority when both the VPLS instance type and the per-peer type are configured.

The examples show the minimum configuration required for enabling a VPLS Mesh peer between PE1, PE2, and PE3 in per peer VPLS-type Signaling.

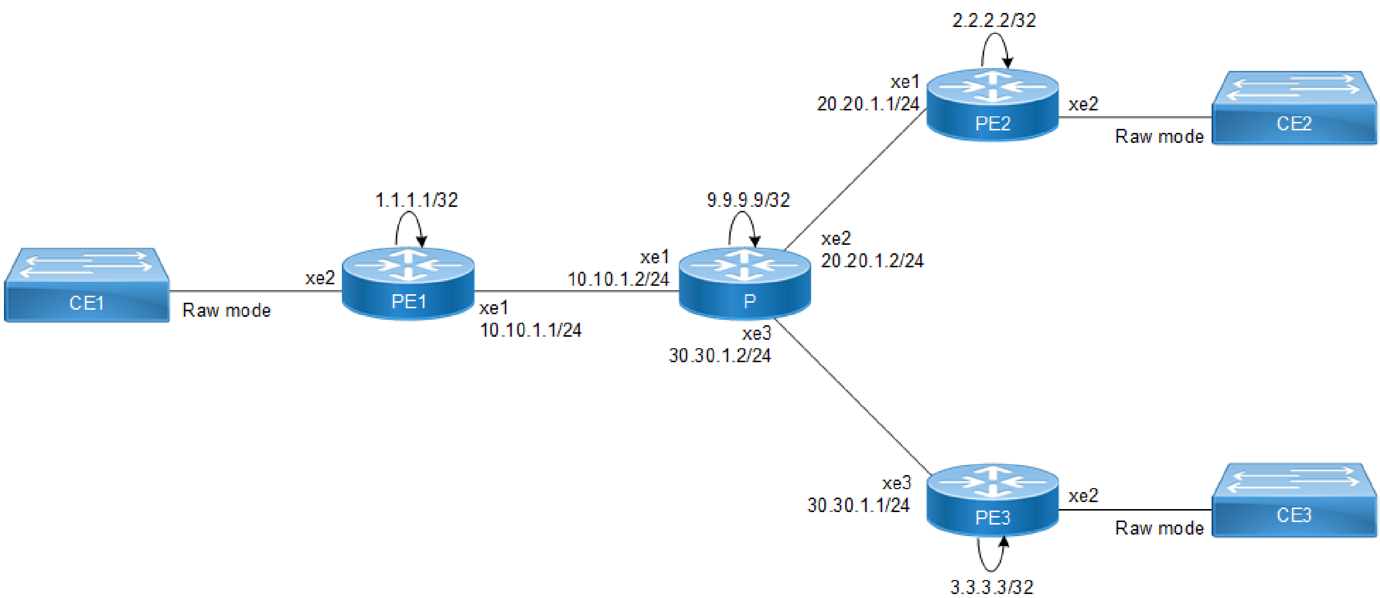

Figure 3-17: VPLS Per Peer VPLS Type Signaling

Configuration

The VPLS BGPSignaling feature enables you to use BGP as the control plane protocol for both auto discovery and signaling in accordance with RFC 4761

PE1 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE1(config)#configure terminal
PE1(config)#interface lo
PE1(config-if)#ip address 1.1.1.1/32 secondary
PE1(config-if)#exit
PE1(config)#interface xe1
PE1(config-if)#ip address 10.10.1.1/24
PE1(config-if)#no shutdown
PE1(config-if)#exit
PE1(config)#router ospf 100
PE1(config-router)#network 10.10.1.0/24 area 0
PE1(config-router)#network 1.1.1.1/32 area 0
PE1(config-router)#exit
PE1(config)#router ldp
PE1(config-router)# router-id 1.1.1.1
```

```
PE1(config-router)#transport-address ipv4 1.1.1.1
PE1(config-router)#targeted-peer ipv4 2.2.2.2
PE1(config-router-targeted-peer)#exit
PE1(config-router)#targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#exit
PE1(config-router)#exit
PE1(config)#interface xe1
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
PE1(config-if)#exit
PE1(config)#mpls vpls VPLS1 100
PE1(config-vpls)#signaling ldp
PE1(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE1(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE1(config-vpls-sig)#exit-signaling
PE1(config-vpls)#exit
PE1(config)#service-template st1
PE1(config-svc)#exit
PE1(config)#interface xe2
PE1(config-if)#switchport
PE1(config-if)mpls-vpls VPLS1 service-template st1
PE1(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE1(config-if-vpls)#exit
PE1(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE1(config)#commit
PE1(config)#copy running-config startup-config
```

P Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
P(config)#configure terminal
P(config)#interface lo
P(config-if)#ip address 9.9.9.9/32 secondary
P(config-if)#exit
P(config)#interface xe1
P(config-if)#ip address 10.10.1.2/24
P(config-if)#exit
P(config)#interface xe2
P(config-if)#ip address 20.20.1.2/24
P(config-if)#exit
P(config)#interface xe3
P(config-if)#ip address 30.30.1.2/24
P(config-if)#exit
P(config)#router ospf 100
P(config-router)#network 10.10.1.0/24 area 0
P(config-router)#network 20.20.1.0/24 area 0
P(config-router)#network 30.30.1.0/24 area 0
P(config-router)#network 9.9.9.9/32 area 0
```

```
P(config-router)#exit
P(config)#router ldp
P(config-router)#router-id 9.9.9.9
P(config-router)#transport-address ipv4 9.9.9.9
P(config-router-targeted-peer)#exit
P(config-router)#exit
P(config)#interface xe1
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(congig-if)#exit
P(config)#interface xe2
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(congig-if)#exit
P(config)#interface xe3
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
```

2. To exit the configuration, execute the following command.

```
P(config-if)exit
```

3. To save the configuration, execute the following command.

```
P(config)#commit
P(config)#copy running-config startup-config
```

PE2 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE2(config)#configure terminal
PE2(config)#interface lo
PE2(config-if)#ip address 2.2.2.2/32 secondary
PE2(config-if)#exit
PE2(config)#interface xe1
PE2(config-if)#ip address 20.20.1.1/24
PE2(config-if)#no shutdown
PE2(config-if)#exit
PE2(config)#router ospf 100
PE2(config-router)#network 20.20.1.0/24 area 0
PE2(config-router)#network 2.2.2.2/32 area 0
PE2(config-router)#exit
PE2(config)#router ldp
PE2(config-router)#router-id 2.2.2.2
PE2(config-router)#transport-address ipv4 2.2.2.2
PE2(config-router)#targeted-peer ipv4 1.1.1.1
PE2(config-router-targeted-peer)#exit
PE2(config-router)#targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#exit
PE2(config-router)#exit
PE2(config)#interface xe1
PE2(config-if)#label-switching
PE2(config-if)#enable-ldp ipv4
PE2(config-if)#exit
```

```
PE2(config)#mpls vpls VPLS1 100
PE2(config-vpls)#signaling ldp
PE2(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE2(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE2(config-vpls-sig)#exit-signaling
PE2(config-vpls)#exit
PE2(config)#service-template st1
PE2(config-svc)#exit
PE2(config)#interface xe2
PE2(config-if)#switchport
PE2(config-if)mpls-vpls VPLS1 service-template st1
PE2(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE2(config-if-vpls)#exit
PE2(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE2(config)#commit
PE2(config)#copy running-config startup-config
```

PE3 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE3(config)#configure terminal
PE3(config)#interface lo
PE3(config-if)#ip address 3.3.3.3/32 secondary
PE3(config-if)#exit
PE3(config)#interface xe1
PE3(config-if)#ip address 30.30.1.1/24
PE3(config-if)#no shutdown
PE3(config-if)#exit
PE3(config)#router ospf 100
PE3(config-router)#network 30.30.1.0/24 area 0
PE3(config-router)#network 3.3.3.3/32 area 0
PE3(config-router)#exit
PE3(config)#router ldp
PE3(config-router)#router-id 3.3.3.3
PE3(config-router)#transport-address ipv4 3.3.3.3
PE3(config-router)#targeted-peer ipv4 1.1.1.1
PE3(config-router-targeted-peer)#exit
PE3(config-router)#targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#exit
PE3(config-router)#exit
PE3(config)#interface xe1
PE3(config-if)#label-switching
PE3(config-if)#enable-ldp ipv4
PE3(config-if)#exit
PE3(config)#mpls vpls VPLS1 100
PE3(config-vpls)#signaling ldp
PE3(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE3(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
```

```
PE3(config-vpls-sig)#exit-signaling
PE3(config-vpls)#exit
PE3(config)#service-template st1
PE3(config-svc)#exit
PE3(config)#interface xe2
PE3(config-if)#switchport
PE3(config-if)mpls-vpls VPLS1 service-template st1
PE3(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE3(config-if-vpls)#exit
PE3(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE3(config)#commit
PE3(config)#copy running-config startup-config
```

Validation

Use this command to validate the Per peer VPLS-type signaling.

PE1 Validation

```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe2
 Service-template : st1
  Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Up)
   3.3.3.3 (Up)
PE1#
PE1#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
```

```
 Operating mode: Raw

 Configured interfaces:
  Interface: xe0
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:55:45)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:55:01)

PE1#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26241
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:55:47

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:55:03
```

Verify VPLS Mesh Peer

```
PE1#show mpls vpls mesh

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
100       2.2.2.2         24325        24321     xe1          24321     2/Up     1
LDP            Active
100       3.3.3.3         24322        24320     xe1          24321     2/Up     2
LDP            Active
```

```
PE1#show ldp session
Peer IP Address  IF Name  My Role  State       KeepAlive UpTime
2.2.2.2          xe1      Passive  OPERATIONAL  30       00:32:21
3.3.3.3          xe1      Passive  OPERATIONAL  30       00:20:50
9.9.9.9          xe1      Passive  OPERATIONAL  30       00:34:18

PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State         Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/Backup   00:00:35   10.10.1.2    xe1      0

P#show ldp session
Peer IP Address  IF Name  My Role  State        KeepAlive UpTime
1.1.1.1          xe1      Active   OPERATIONAL  30        00:40:04
2.2.2.2          xe2      Active   OPERATIONAL  30        00:38:22
3.3.3.3          xe3      Active   OPERATIONAL  30        00:25:57

P#show ip ospf neighbor
Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface  Instance ID
10.12.49.142   1  Full/DR    00:00:34  10.10.1.1   xe1       0
10.12.49.144   1  Full/Backup   00:00:29  20.20.1.1   xe2  0
10.12.49.146   1  Full/Backup   00:00:36  30.30.1.1   xe3  0

P#show mpls vpls detail


P#show ldp vpls detail



PE2#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe14
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all
```

```
 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:17:37)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:08)

PE2#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26241
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:17:53

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:19:24

PE2#show mpls vpls mesh
VPLS-ID  Peer Addr  Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX
SIG-Protocol Status
100      1.1.1.1   25601       26240     xe1         26240    2/Up     1      LDP
Active
100      3.3.3.3   25603       26241     xe1         26241    2/Up     2      LDP
Active

PE2#show ldp session
Peer IP Address     IF Name  My Role  State        KeepAlive UpTime
1.1.1.1             xe1      Active   OPERATIONAL  30        00:41:59
3.3.3.3             xe1      Passive  OPERATIONAL  30        00:30:15
9.9.9.9             xe1      Passive  OPERATIONAL  30        00:42:14

PE2#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID   Pri  State     Dead Time  Address    Interface      Instance ID
10.12.49.145   1  Full/DR    00:00:35  20.20.1.2   xe1            0
```

```
PE3#show ldp session
Peer IP Address IF Name  My Role  State   KeepAlive UpTime
1.1.1.1         xe1   Active  OPERATIONAL  30  00:44:25
2.2.2.2         xe1   Active  OPERATIONAL  30  00:44:13
9.9.9.9         xe1   Passive  OPERATIONAL  30  00:43:47

PE3#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/DR    00:00:33  30.30.1.2   xe1       0

PE3#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
 Interface: xe2
Service-template : st1
Match criteria : Accept all

Mesh Peers:
 1.1.1.1 (Up)
 2.2.2.2 (Up)

PE3#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe3
   Status: Up
   Split-horizon group : access1
   Service-template : st1
```

```
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:16:54)
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:09)


PE3#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26241
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:17:09

 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:19:24


PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VPLS-ID  Peer Addr    Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX
SIG-Protocol Status
100      1.1.1.1    25602      26240    xe1         26241      2/Up     ]     LDP
Active
100      2.2.2.2    25603      26241    xe1         26241      2/Up     2     LDP
Active
```

VPLS - Tunnel-ID

Overview

Virtual Private LAN Service (VPLS) is a Layer 2 VPN technology that allows geographically dispersed sites to share an Ethernet broadcast domain by connecting them through a service provider's MPLS network. This effectively creates a single, bridged Ethernet LAN across multiple sites.

VPLS with Tunnel-IDs provides a robust solution for extending Ethernet LAN services over a wide area network. The use of Tunnel-IDs ensures efficient and reliable delivery of Ethernet frames across the MPLS core, enabling service providers to offer high-quality, scalable, and flexible VPN services to their customers.

Feature Characteristics

Tunnel-IDs in VPLS are essential for efficient and reliable operation due to their unique identification, support for scalability, dynamic allocation by protocols like LDP or BGP, and compatibility with various signaling methods. They enable precise traffic engineering and load balancing, enhance resilience through fast reroute mechanisms and redundancy, and improve security with traffic isolation and access control. Additionally, Tunnel-IDs facilitate network management and monitoring by providing visibility into network paths and performance metrics, and they ensure compatibility with existing infrastructure for seamless integration of new services.

The examples show the minimum configuration required for enabling a VPLS Tunnel-ID between PE1, PE2, and PE3.

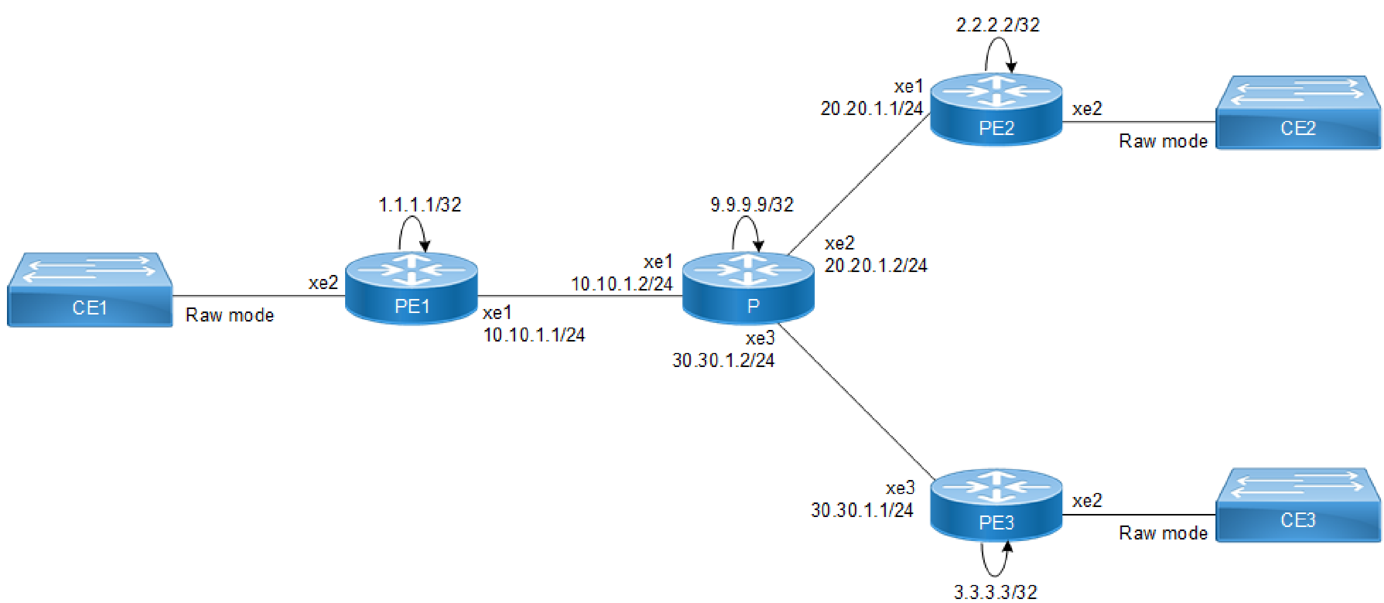

Figure 3-18: VPLS Tunnel-ID

Configuration

The VPLS Tunnel-ID feature enables you to use BGP as the control plane protocol for both auto discovery and signaling in accordance with RFC 4761

PE1 Configuration

1. To enable the VPLS-Tunnel-ID, execute the following command in the config mode

```
PE1(config)#configure terminal
```

```
PE1(config)#interface lo
PE1(config-if)#ip address 1.1.1.1/32 secondary
PE1(config-if)#exit
PE1(config)#interface xe1
PE1(config-if)#ip address 10.10.1.1/24
PE1(config-if)#no shutdown
PE1(config-if)#exit
PE1(config)#router ospf 100
PE1(config-router)#network 10.10.1.0/24 area 0
PE1(config-router)#network 1.1.1.1/32 area 0
PE1(config-router)#exit
PE1(config)#router ldp
PE1(config-router)# router-id 1.1.1.1
PE1(config-router)#transport-address ipv4 1.1.1.1
PE1(config-router)#targeted-peer ipv4 2.2.2.2
PE1(config-router-targeted-peer)#exit
PE1(config-router)#targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#exit
PE1(config-router)#exit
PE1(config)#interface xe1
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
PE1(config-if)#exit
PE1(config)#mpls vpls VPLS1 100
PE1(config-vpls)#signaling ldp
PE1(config-vpls-sig) #mpls ftn-entry tunnel-id 100 2.2.2.2/32 200 10.10.1.2 xe1 
primary
PE1(config-vpls-sig) #mpls ftn-entry tunnel-id 300 3.3.3.3/32 400 10.10.1.2 xe1 
primary
PE1(config-vpls-sig)#exit-signaling
PE1(config-vpls)#exit
PE1(config)#service-template st1
PE1(config-svc)#exit
PE1(config)#interface xe2
PE1(config-if)#switchport
PE1(config-if)mpls-vpls VPLS1 service-template st1
PE1(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE1(config-if-vpls)#exit
PE1(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE1(config)#commit
PE1(config)#copy running-config startup-config
```

P Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
P(config)#configure terminal
P(config)#interface lo
P(config-if)#ip address 9.9.9.9/32 secondary
```

```
P(config-if)#exit
P(config)#interface xe1
P(config-if)#ip address 10.10.1.2/24
P(config-if)#exit
P(config)#interface xe2
P(config-if)#ip address 20.20.1.2/24
P(config-if)#exit
P(config)#interface xe3
P(config-if)#ip address 30.30.1.2/24
P(config-if)#exit
P(config)#router ospf 100
P(config-router)#network 10.10.1.0/24 area 0
P(config-router)#network 20.20.1.0/24 area 0
P(config-router)#network 30.30.1.0/24 area 0
P(config-router)#network 9.9.9.9/32 area 0
P(config-router)#exit
P(config)#router ldp
P(config-router)#router-id 9.9.9.9
P(config-router)#transport-address ipv4 9.9.9.9
P(config-router-targeted-peer)#exit
P(config-router)#exit
P(config)#interface xe1
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(congig-if)#exit
P(config)#interface xe2
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(congig-if)#exit
P(config)#interface xe3
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
```

2. To exit the configuration, execute the following command.

```
P(config-if)exit
```

3. To save the configuration, execute the following command.

```
P(config)#commit
P(config)#copy running-config startup-config
```

PE2 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE2(config)#configure terminal
PE2(config)#interface lo
PE2(config-if)#ip address 2.2.2.2/32 secondary
PE2(config-if)#exit
PE2(config)#interface xe1
PE2(config-if)#ip address 20.20.1.1/24
PE2(config-if)#no shutdown
PE2(config-if)#exit
PE2(config)#router ospf 100
```

```
PE2(config-router)#network 20.20.1.0/24 area 0
PE2(config-router)#network 2.2.2.2/32 area 0
PE2(config-router)#exit
PE2(config)#router ldp
PE2(config-router)#router-id 2.2.2.2
PE2(config-router)#transport-address ipv4 2.2.2.2
PE2(config-router)#targeted-peer ipv4 1.1.1.1
PE2(config-router-targeted-peer)#exit
PE2(config-router)#targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#exit
PE2(config-router)#exit
PE2(config)#interface xe1
PE2(config-if)#label-switching
PE2(config-if)#enable-ldp ipv4
PE2(config-if)#exit
PE2(config)#mpls vpls VPLS1 100
PE2(config-vpls)#signaling ldp
PE2(config-vpls-sig) #mpls ftn-entry tunnel-id 200 1.1.1.1/32 100 20.20.1.2 xe16 primary
PE2(config-vpls-sig)#exit-signaling
PE2(config-vpls)#exit
PE2(config)#service-template st1
PE2(config-svc)#exit
PE2(config)#interface xe2
PE2(config-if)#switchport
PE2(config-if)mpls-vpls VPLS1 service-template st1
PE2(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE2(config-if-vpls)#exit
PE2(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE2(config)#commit
PE2(config)#copy running-config startup-config
```

PE3 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE3(config)#configure terminal
PE3(config)#interface lo
PE3(config-if)#ip address 3.3.3.3/32 secondary
PE3(config-if)#exit
PE3(config)#interface xe1
PE3(config-if)#ip address 30.30.1.1/24
PE3(config-if)#no shutdown
PE3(config-if)#exit
PE3(config)#router ospf 100
PE3(config-router)#network 30.30.1.0/24 area 0
PE3(config-router)#network 3.3.3.3/32 area 0
PE3(config-router)#exit
PE3(config)#router ldp
```

```
PE3(config-router)#router-id 3.3.3.3
PE3(config-router)#transport-address ipv4 3.3.3.3
PE3(config-router)#targeted-peer ipv4 1.1.1.1
PE3(config-router-targeted-peer)#exit
PE3(config-router)#targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#exit
PE3(config-router)#exit
PE3(config)#interface xe1
PE3(config-if)#label-switching
PE3(config-if)#enable-ldp ipv4
PE3(config-if)#exit
PE3(config)#mpls vpls VPLS1 100
PE3(config-vpls)#signaling ldp
PE3(config-vpls-sig) #mpls ftn-entry tunnel-id 400 1.1.1.1/32 300 30.30.1.2 xe21 
primary
PE3(config-vpls-sig)#exit-signaling
PE3(config-vpls)#exit
PE3(config)#service-template st1
PE3(config-svc)#exit
PE3(config)#interface xe2
PE3(config-if)#switchport
PE3(config-if)mpls-vpls VPLS1 service-template st1
PE3(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE3(config-if-vpls)#exit
PE3(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE3(config)#commit
PE3(config)#copy running-config startup-config
```

Validation

Use this command to validate the Per peer VPLS-type signaling.

PE1 Validation

```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe2
 Service-template : st1
  Match criteria : Accept all
```

```
 Mesh Peers:
   2.2.2.2 (Up)
   3.3.3.3 (Up)
PE1#
PE1#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe0
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:55:45)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:55:01)

PE1#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26241
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:55:47

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
```

```
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:55:03
```

Verify VPLS Mesh Peer

```
PE1#show mpls vpls mesh

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
100       2.2.2.2         24325        24321     xe1          24321     2/Up     1
LDP            Active
100       3.3.3.3         24322        24320     xe1          24321     2/Up     2
LDP            Active

PE1#show ldp session
Peer IP Address   IF Name  My Role  State       KeepAlive UpTime
2.2.2.2           xe1      Passive  OPERATIONAL  30       00:32:21
3.3.3.3           xe1      Passive  OPERATIONAL  30       00:20:50
9.9.9.9           xe1      Passive  OPERATIONAL  30       00:34:18

PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State         Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/Backup   00:00:35   10.10.1.2    xe1      0
PE1#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe0
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 04:17:22)
   Tunnel-Id: 100
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:00:49)
   Tunnel-Id: 300
```

```
PE1#
PE1#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26240
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 04:17:33

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26241
 VC Label Received  : 26242
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:01:01
PE1#

P#show ldp session
Peer IP Address  IF Name  My Role  State        KeepAlive UpTime
1.1.1.1          xe1      Active   OPERATIONAL  30        00:40:04
2.2.2.2          xe2      Active   OPERATIONAL  30        00:38:22
3.3.3.3          xe3      Active   OPERATIONAL  30        00:25:57

P#show ip ospf neighbor
Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface  Instance ID
10.12.49.142   1  Full/DR    00:00:34  10.10.1.1   xe1       0
10.12.49.144   1  Full/Backup   00:00:29  20.20.1.1   xe2  0
10.12.49.146   1  Full/Backup   00:00:36  30.30.1.1   xe3  0

PE1#show running-config vpls
!
mpls vpls VPLS1 100
 signaling ldp
  vpls-peer 2.2.2.2 tunnel-id 100 vpls-type vlan
  vpls-peer 3.3.3.3 tunnel-id 300 vpls-type ethernet
```

```
  exit-signaling
 exit-vpls
!
!
interface xe0
 mpls-vpls VPLS1 service-template st1
    split-horizon group access1
!
PE1#

PE2#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe14
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:17:37)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:08)

PE2#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26241
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:17:53

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
```

```
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:19:24

PE2#show mpls vpls mesh
VPLS-ID  Peer Addr  Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX
SIG-Protocol Status
100      1.1.1.1   25601       26240     xe1         26240    2/Up     1      LDP
Active
100      3.3.3.3   25603       26241     xe1         26241    2/Up     2      LDP
Active

PE2#show ldp session
Peer IP Address     IF Name  My Role  State        KeepAlive UpTime
1.1.1.1             xe1      Active   OPERATIONAL  30        00:41:59
3.3.3.3             xe1      Passive  OPERATIONAL  30        00:30:15
9.9.9.9             xe1      Passive  OPERATIONAL  30        00:42:14

PE2#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface      Instance ID
10.12.49.145   1  Full/DR    00:00:35  20.20.1.2   xe1            0

PE2#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe14
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 04:16:11)
```

```
   Tunnel-Id: 200

PE2#

PE2#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26241
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 04:17:55
PE2#


PE3#show ldp session
Peer IP Address IF Name  My Role  State   KeepAlive UpTime
1.1.1.1         xe1   Active  OPERATIONAL  30  00:44:25
2.2.2.2         xe1   Active  OPERATIONAL  30  00:44:13
9.9.9.9         xe1   Passive  OPERATIONAL  30  00:43:47

PE3#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/DR    00:00:33  30.30.1.2   xe1       0

PE2#show running-config vpls
!
mpls vpls VPLS1 100
 signaling ldp
  vpls-peer 1.1.1.1 tunnel-id 200 vpls-type vlan
  exit-signaling
 exit-vpls
!
!
interface xe14
 mpls-vpls VPLS1 service-template st1
    split-horizon group access1
!
PE2#

PE3#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
```

```
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
 Interface: xe2
Service-template : st1
Match criteria : Accept all

Mesh Peers:
 1.1.1.1 (Up)
 2.2.2.2 (Up)

PE3#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe3
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:16:54)
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:09)


PE3#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26241
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
```

```
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:17:09

 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:19:24


PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VPLS-ID  Peer Addr    Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX
SIG-Protocol Status
100      1.1.1.1    25602       26240    xe1         26241      2/Up     ]     LDP
Active
100      2.2.2.2    25603       26241    xe1         26241      2/Up     2     LDP
Active
PE3#show running-config vpls
!
mpls vpls VPLS1 100
 signaling ldp
  vpls-peer 1.1.1.1 tunnel-id 400 vpls-type ethernet
  exit-signaling
 exit-vpls
!
!
interface xe3
 mpls-vpls VPLS1 service-template st1
    split-horizon group access1
!
PE3#
PE3#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
```

```
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe3
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:00:05)
   Tunnel-Id: 400

PE3#

PE3#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26242
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:01:44
PE3#
```

VPLS - Tunnel-Name

Overview

Virtual Private LAN Service (VPLS) is a Layer 2 VPN technology that allows geographically dispersed sites to share a common Ethernet broadcast domain, functioning as if they were all connected to the same LAN. This setup enables any-to-any communication between sites, providing the appearance of a single, cohesive LAN across multiple locations.

VPLS - Tunnel-Name is a configuration element within a VPLS network that is used to identify and manage MPLS tunnels. When configuring a VPLS instance on a network device, the Tunnel-Name is assigned to each MPLS tunnel. This can typically be done in the device’s CLI under the VPLS configuration mode.

The "VPLS - Tunnel-Name" is a vital element in the configuration and management of VPLS networks. By providing unique identifiers for MPLS tunnels, it enhances the organization, management, and troubleshooting of VPLS instances, ultimately leading to more efficient and reliable network operations.

Feature Characteristics

The VPLS - Tunnel-Name feature in a VPLS network enhances functionality, manageability, and efficiency by providing unique identification for MPLS tunnels, simplifying network management, and improving troubleshooting. It allows granular control over configurations and policies, supports scalability and future network expansions, enhances security through controlled access and traffic isolation, and ensures redundancy and reliability by managing backup tunnels effectively. Additionally, it streamlines operations and reduces configuration errors, making it an essential tool for maintaining robust and reliable VPLS networks.

The examples show the minimum configuration required for enabling a VPLS Tunnel-Name between PE1, PE2, and PE3.

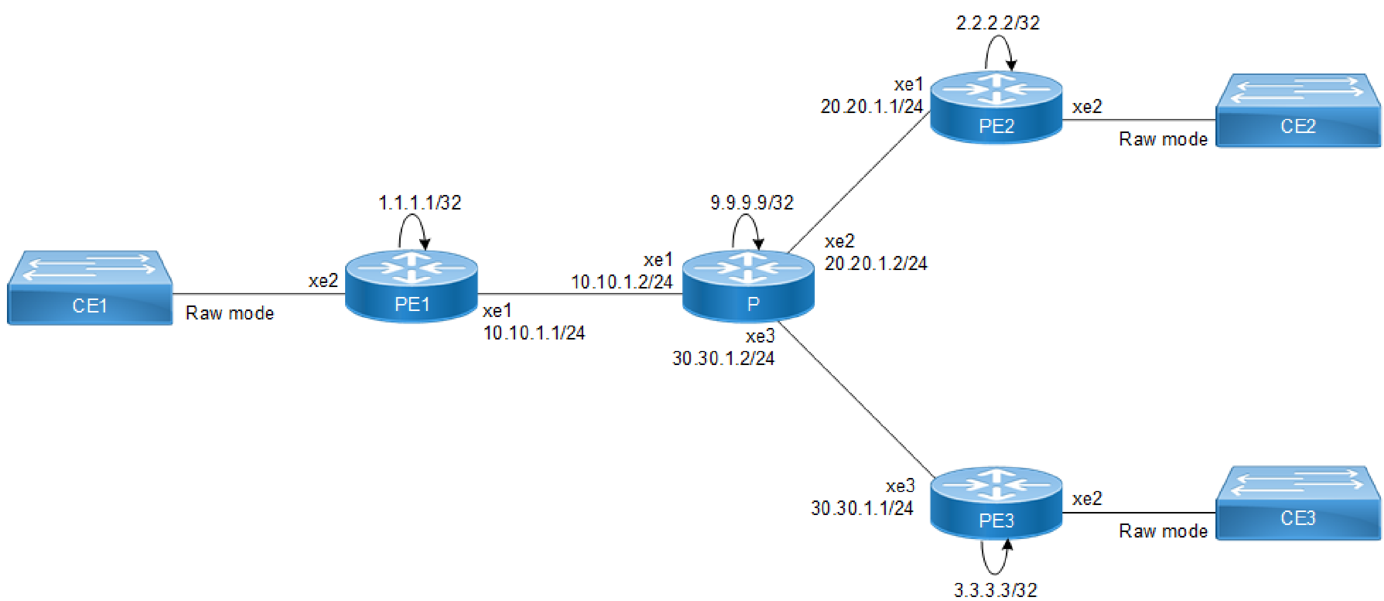

Figure 3-19: VPLS Tunnel-Name

Configuration

The VPLS Tunnel-Name feature enables you to use BGP as the control plane protocol for both auto discovery and signaling in accordance with RFC 4761

PE1 Configuration

1. To enable the per peer VPLS-Tunnel-Name, execute the following command in the config mode

```
PE1(config)#configure terminal
PE1(config)#interface lo
PE1(config-if)#ip address 1.1.1.1/32 secondary
PE1(config-if)#exit
PE1(config)#interface xe1
PE1(config-if)#ip address 10.10.1.1/24
PE1(config-if)#no shutdown
PE1(config-if)#exit
PE1(config)#router ospf 100
PE1(config-router)#network 10.10.1.0/24 area 0
PE1(config-router)#network 1.1.1.1/32 area 0
PE1(config-router)#exit
```

```
PE1(config)#router ldp
PE1(config-router)# router-id 1.1.1.1
PE1(config-router)#transport-address ipv4 1.1.1.1
PE1(config-router)#targeted-peer ipv4 2.2.2.2
PE1(config-router-targeted-peer)#exit
PE1(config-router)#targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#exit
PE1(config-router)#exit
PE1(config)#interface xe1
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
PE1(config-if)#exit
PE1(config)#mpls vpls VPLS1 100
PE1(config-vpls)#signaling ldp
PE1(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE1(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE1(config-vpls-sig)#exit-signaling
PE1(config-vpls)#exit
PE1(config)#service-template st1
PE1(config-svc)#exit
PE1(config)#interface xe2
PE1(config-if)#switchport
PE1(config-if)mpls-vpls VPLS1 service-template st1
PE1(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE1(config-if-vpls)#exit
PE1(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE1(config)#commit
PE1(config)#copy running-config startup-config
```

P Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
P(config)#configure terminal
P(config)#interface lo
P(config-if)#ip address 9.9.9.9/32 secondary
P(config-if)#exit
P(config)#interface xe1
P(config-if)#ip address 10.10.1.2/24
P(config-if)#exit
P(config)#interface xe2
P(config-if)#ip address 20.20.1.2/24
P(config-if)#exit
P(config)#interface xe3
P(config-if)#ip address 30.30.1.2/24
P(config-if)#exit
P(config)#router ospf 100
P(config-router)#network 10.10.1.0/24 area 0
P(config-router)#network 20.20.1.0/24 area 0
```

```
P(config-router)#network 30.30.1.0/24 area 0
P(config-router)#network 9.9.9.9/32 area 0
P(config-router)#exit
P(config)#router ldp
P(config-router)#router-id 9.9.9.9
P(config-router)#transport-address ipv4 9.9.9.9
P(config-router-targeted-peer)#exit
P(config-router)#exit
P(config)#interface xe1
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(congig-if)#exit
P(config)#interface xe2
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
P(congig-if)#exit
P(config)#interface xe3
P(config-if)#label-switching
P(config-if)#enable-ldp ipv4
```

2. To exit the configuration, execute the following command.

```
P(config-if)exit
```

3. To save the configuration, execute the following command.

```
P(config)#commit
P(config)#copy running-config startup-config
```

PE2 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE2(config)#configure terminal
PE2(config)#interface lo
PE2(config-if)#ip address 2.2.2.2/32 secondary
PE2(config-if)#exit
PE2(config)#interface xe1
PE2(config-if)#ip address 20.20.1.1/24
PE2(config-if)#no shutdown
PE2(config-if)#exit
PE2(config)#router ospf 100
PE2(config-router)#network 20.20.1.0/24 area 0
PE2(config-router)#network 2.2.2.2/32 area 0
PE2(config-router)#exit
PE2(config)#router ldp
PE2(config-router)#router-id 2.2.2.2
PE2(config-router)#transport-address ipv4 2.2.2.2
PE2(config-router)#targeted-peer ipv4 1.1.1.1
PE2(config-router-targeted-peer)#exit
PE2(config-router)#targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#exit
PE2(config-router)#exit
PE2(config)#interface xe1
PE2(config-if)#label-switching
```

```
PE2(config-if)#enable-ldp ipv4
PE2(config-if)#exit
PE2(config)#mpls vpls VPLS1 100
PE2(config-vpls)#signaling ldp
PE2(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE2(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE2(config-vpls-sig)#exit-signaling
PE2(config-vpls)#exit
PE2(config)#service-template st1
PE2(config-svc)#exit
PE2(config)#interface xe2
PE2(config-if)#switchport
PE2(config-if)mpls-vpls VPLS1 service-template st1
PE2(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE2(config-if-vpls)#exit
PE2(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE2(config)#commit
PE2(config)#copy running-config startup-config
```

PE3 Configuration

1. To enable the per peer VPLS-type signaling, execute the following command in the config mode

```
PE3(config)#configure terminal
PE3(config)#interface lo
PE3(config-if)#ip address 3.3.3.3/32 secondary
PE3(config-if)#exit
PE3(config)#interface xe1
PE3(config-if)#ip address 30.30.1.1/24
PE3(config-if)#no shutdown
PE3(config-if)#exit
PE3(config)#router ospf 100
PE3(config-router)#network 30.30.1.0/24 area 0
PE3(config-router)#network 3.3.3.3/32 area 0
PE3(config-router)#exit
PE3(config)#router ldp
PE3(config-router)#router-id 3.3.3.3
PE3(config-router)#transport-address ipv4 3.3.3.3
PE3(config-router)#targeted-peer ipv4 1.1.1.1
PE3(config-router-targeted-peer)#exit
PE3(config-router)#targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#exit
PE3(config-router)#exit
PE3(config)#interface xe1
PE3(config-if)#label-switching
PE3(config-if)#enable-ldp ipv4
PE3(config-if)#exit
PE3(config)#mpls vpls VPLS1 100
PE3(config-vpls)#signaling ldp
```

```
PE3(config-vpls-sig)#vpls-peer 2.2.2.2 vpls-type vlan
PE3(config-vpls-sig)#vpls-peer 3.3.3.3 vpls-type ethernet
PE3(config-vpls-sig)#exit-signaling
PE3(config-vpls)#exit
PE3(config)#service-template st1
PE3(config-svc)#exit
PE3(config)#interface xe2
PE3(config-if)#switchport
PE3(config-if)mpls-vpls VPLS1 service-template st1
PE3(config-if-vpls)#split-horizon group access1
```

2. To exit the configuration, execute the following command.

```
PE3(config-if-vpls)#exit
PE3(config-if)exit
```

3. To save the configuration, execute the following command.

```
PE3(config)#commit
PE3(config)#copy running-config startup-config
```

Validation

Use this command to validate the Per peer VPLS-type signaling.

PE1 Validation

```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe2
 Service-template : st1
  Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Up)
   3.3.3.3 (Up)
PE1#

PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to 
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
```

```
Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
2.2.2.2        1.1.1.1        5001    2203    PRI   PE1_to_PE2-Primary            UP
00:04:19  1 1 SE     -        27522
3.3.3.3        1.1.1.1        5002    2201    PRI   PE1_to_PE3-Primary            UP
00:00:15  1 1 SE     -        27523
Total 2 displayed, Up 2, Down 0.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
1.1.1.1        2.2.2.2        5001    2201    PRI   PE2_to_PE1-Primary            UP
00:05:38  1 1 SE     29440    -
1.1.1.1        3.3.3.3        5001    2201    PRI   PE3_to_PE1-Primary            UP
00:00:25  1 1 SE     29441    -
Total 2 displayed, Up 2, Down 0.

PE1#

PE1#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe0
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:55:45)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:55:01)

PE1#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26241
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
```

```
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:55:47

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:55:03
PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime
100        2.2.2.2          27522         26242      xe1            26244      2/Up
1         LDP           Active     00:02:14
100        3.3.3.3          27523         26241      xe1            26242      2/Up
2         LDP           Active     00:00:52
PE1#
PE1#
PE1#
PE1#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe0
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:02:21)
```

```
   Tunnel-Name: PE1_to_PE2
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:00:59)
   Tunnel-Name: PE1_to_PE3

PE1#
PE1#
PE1#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26242
 VC Label Received  : 26243
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:02:25

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26241
 VC Label Received  : 26242
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:01:03
PE1#
```

Verify VPLS Mesh Peer

```
PE1#show mpls vpls mesh

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
100      2.2.2.2         24325        24321     xe1          24321     2/Up     1
LDP           Active
100      3.3.3.3         24322        24320     xe1          24321     2/Up     2
LDP           Active

PE1#show ldp session
Peer IP Address  IF Name  My Role  State       KeepAlive UpTime
2.2.2.2          xe1      Passive  OPERATIONAL  30       00:32:21
3.3.3.3          xe1      Passive  OPERATIONAL  30       00:20:50
9.9.9.9          xe1      Passive  OPERATIONAL  30       00:34:18
```

```
PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State          Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/Backup    00:00:35   10.10.1.2    xe1       0

PE1#show running-config vpls
!
mpls vpls VPLS1 100
 signaling ldp
  vpls-peer 2.2.2.2 tunnel-name PE1_to_PE2 vpls-type vlan
  vpls-peer 3.3.3.3 tunnel-name PE1_to_PE3 vpls-type ethernet
  exit-signaling
 exit-vpls
!
!
interface xe0
 mpls-vpls VPLS1 service-template st1
    split-horizon group access1
!
PE1#

PE2#show run rsvp
!
router rsvp
!
!
interface xe16
 enable-rsvp
!
!
!
rsvp-path PE2_to_PE1 mpls
 20.20.1.2 strict
 10.10.1.1 strict
!
!
!
rsvp-trunk PE2_to_PE1 ipv4
 primary path PE2_to_PE1
 to 1.1.1.1
!
!
PE2#

PE2#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to 
Secondary
* indicates the session is active with local repair at one or more nodes
```

```
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
1.1.1.1        2.2.2.2        5001    2201    PRI   PE2_to_PE1-Primary            UP
00:06:36  1 1 SE     -        27520
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
2.2.2.2        1.1.1.1        5001    2203    PRI   PE1_to_PE2-Primary            UP
00:05:16  1 1 SE     28801    -
Total 1 displayed, Up 1, Down 0.

PE2#
PE2#show running-config vpls
!
mpls vpls VPLS1 100
 signaling ldp
  vpls-peer 1.1.1.1 tunnel-name PE2_to_PE1 vpls-type vlan
  exit-signaling
 exit-vpls
!
!
interface xe14
 mpls-vpls VPLS1 service-template st1
    split-horizon group access1
!
PE2#
PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime
100       1.1.1.1          27520         26243      xe16           26242      2/Up
1         LDP           Active     00:03:24
PE2#
PE2#
PE2#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
```

```
 Configured interfaces:
  Interface: xe14
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:03:30)
   Tunnel-Name: PE2_to_PE1

PE2#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26243
 VC Label Received  : 26242
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:03:33
PE2#


PE2#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe14
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet VLAN) (Up) (UpTime: 00:17:37)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:08)
```

```
PE2#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 26241
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:17:53

 VPLS Identifier    : 100
 Peer IP            : 3.3.3.3
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:19:24

PE2#show mpls vpls mesh
VPLS-ID  Peer Addr  Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX
SIG-Protocol Status
100      1.1.1.1   25601       26240     xe1         26240    2/Up     1      LDP
Active
100      3.3.3.3   25603       26241     xe1         26241    2/Up     2      LDP
Active

PE2#show ldp session
Peer IP Address     IF Name  My Role  State        KeepAlive UpTime
1.1.1.1             xe1      Active   OPERATIONAL  30        00:41:59
3.3.3.3             xe1      Passive  OPERATIONAL  30        00:30:15
9.9.9.9             xe1      Passive  OPERATIONAL  30        00:42:14

PE2#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface      Instance ID
10.12.49.145   1  Full/DR    00:00:35  20.20.1.2   xe1           0

PE3#show run rsvp
!
router rsvp
```

```
!
!
interface xe21
 enable-rsvp
!
!
!
rsvp-path PE3_to_PE1 mpls
 30.30.1.2 strict
 10.10.1.1 strict
!
!
!
rsvp-trunk PE3_to_PE1 ipv4
 primary path PE3_to_PE1
 to 1.1.1.1
!
!
PE3#
PE3#show running-config vpls
!
mpls vpls VPLS1 100
 signaling ldp
  vpls-peer 1.1.1.1 tunnel-name PE3_to_PE1 vpls-type ethernet
  exit-signaling
 exit-vpls
!
!
interface xe3
 mpls-vpls VPLS1 service-template st1
    split-horizon group access1
!


PE3#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
1.1.1.1        3.3.3.3        5001    2201    PRI   PE3_to_PE1-Primary            UP
00:01:38  1 1 SE     -        27521
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
```

```
3.3.3.3       1.1.1.1       5002    2201    PRI    PE1_to_PE3-Primary           UP
00:01:28  1 1 SE     30080    -
Total 1 displayed, Up 1, Down 0.

PE3#show ldp session
Peer IP Address IF Name  My Role  State   KeepAlive UpTime
1.1.1.1         xe1   Active  OPERATIONAL  30  00:44:25
2.2.2.2         xe1   Active  OPERATIONAL  30  00:44:13
9.9.9.9         xe1   Passive  OPERATIONAL  30  00:43:47

PE3#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID  Pri  State     Dead Time  Address    Interface  Instance ID
10.12.49.145   1  Full/DR    00:00:33  30.30.1.2   xe1       0

PE3#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Configured interfaces:
 Interface: xe2
Service-template : st1
Match criteria : Accept all

Mesh Peers:
 1.1.1.1 (Up)
 2.2.2.2 (Up)

PE3#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe3
   Status: Up
```

```
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:16:54)
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:19:09)


PE3#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26241
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:17:09

 VPLS Identifier    : 100
 Peer IP            : 2.2.2.2
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26240
 VC Label Received  : 26240
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:19:24


PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VPLS-ID  Peer Addr    Tunnel-Label In-Label  Network-Intf  Out-Label Lkps/St  PW-INDEX
SIG-Protocol Status
100      1.1.1.1    25602       26240    xe1         26241      2/Up     ]     LDP
Active
100      2.2.2.2    25603       26241    xe1         26241      2/Up     2     LDP
Active
PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

```
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime
100        1.1.1.1          27521         26242      xe21           26241      2/Up
1         LDP           Active     00:01:40
PE3#
PE3#show mpls vpls VPLS1
Virtual Private LAN Service Instance: VPLS1, ID: 100
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe3
   Status: Up
   Split-horizon group : access1
   Service-template : st1
   Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Peer VPLS Type: Ethernet) (Up) (UpTime: 00:01:45)
   Tunnel-Name: PE3_to_PE1

PE3#
PE3#show ldp vpls 100
 VPLS Identifier    : 100
 Peer IP            : 1.1.1.1
 VC State           : UP
 VC Type            : ethernet
 VC Label Sent      : 26242
 VC Label Received  : 26241
 Local  MTU         : 1500
 Remote MTU         : 1500
 Local PW Status Capability : disabled
 Remote PW Status Capability : disabled
 Current PW Status TLV : disabled
 LDP-VPLS Signaled Time  : 00:01:50
PE3#
```

CHAPTER 4 Static VPLS Configuration

This chapter includes step-by-step configurations for Static VPLS. It also contains an overview of the concepts of Static VPLS.

Overview

Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP-MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. A set of Martini circuits is grouped by a common VPLS identifier to achieve this service objective.

A pseudowire (PW) consists of a pair of point-to-point, single-hop unidirectional LSPs in opposite directions, each identified by a PW label, also called a Virtual Connection (VC) label.

The Label Distribution Protocol (LDP) is used to signal constituent VCs, and the service provider may use either LDP or RSVP-TE or add static provisioning to set up LSP tunnels to transport data through virtual circuits.

The VPLS identifier is exchanged with the labels, so that both PWs can be linked and be associated with a particular VPLS instance.

Configure Static VPLS

In the following examples, VPLS (v1) is configured on PE-2 with Static VPLS-Peers PE-1 and PE-3 using static LSPs.

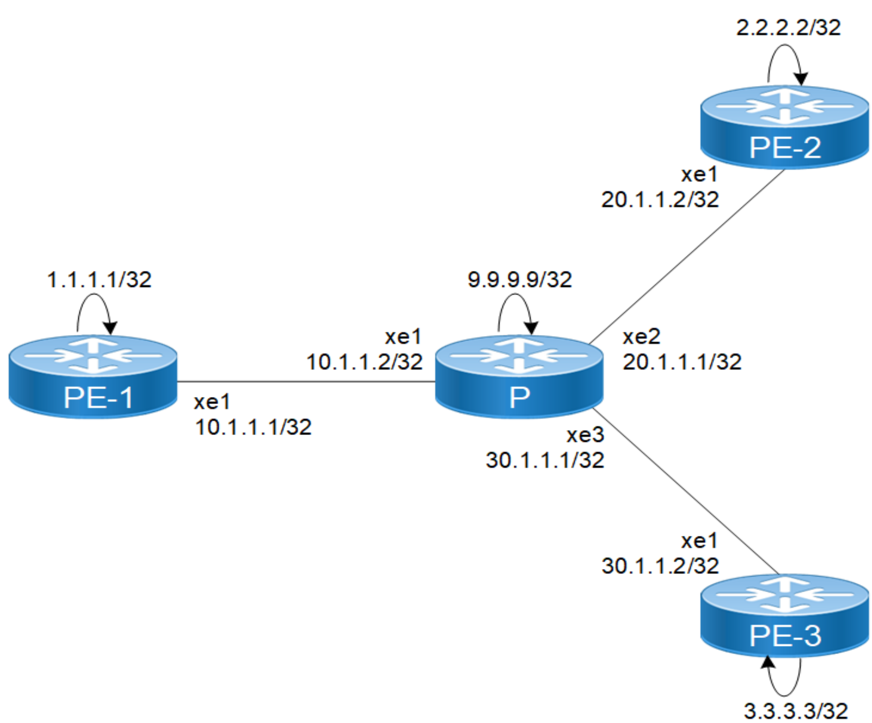

Figure 4-20: Static Virtual Private LAN Service Topology

PE-1

`#configure terminal`	Enter configure mode.
`(config)#mpls ftn-entry tunnel-id 11 2.2.2.2/32 102 10.10.1.2 xe1 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE-2.
`(config)#mpls ftn-entry tunnel-id 22 3.3.3.3/32 103 10.10.1.2 xe1 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE-3.
`(config)#mpls ilm-entry 201 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE-2.
`(config)#mpls ilm-entry 301 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE-3.
`(config)#mpls vpls v1 100`	Configure VPLS `v1` with ID `100` on PE-1.
`(config-vpls)#vpls-peer 2.2.2.2 tunnel-id 11 manual`	Configure PE-2 as a manual VPLS peer using the static LSP tunnel ID `11`
`(config-vpls)#vpls-peer 3.3.3.3 tunnel-id 22 manual`	Configure PE-3 as a manual VPLS peer using the static LSP tunnel ID `22`.
`(config-vpls)#exit`	Exit Configure VPLS mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.1.1/24`	Configure IP address for the interface.
`(config-if)#label-switching`	Enable label switching capability on the interface.
`(config-if)#exit`	Exit interface mode
`(config)#interface lo`	Enter interface mode
`(config-if)#ip address 1.1.1.1/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 100`	Configure the routing process and specify the routing `process ID(100)`.
`(config-router)#ospf router-id 1.1.1.1`	Configure OSPF router id same as loopback IP address
`(config-router)#transport-address ipv4 1.1.1.1`	Configure transport address as loopback address.
`(config-router)#targeted-peer ipv4 3.3.3.3`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#network 10.10.1.0/24 area 0`	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
`(config-router)#network 1.1.1.1/32 area 0`	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
`(config-router)#exit`	Exit router mode
`(config)#service-template st1`	Template configuration
`(config-svc)#exit`	Exit service template mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#mpls-vpls v1 service-template st1`	Bind the VPLS to the Access Interface.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)#exit`	Exit interface mode.

(config)#vpls fib-entry 100 peer 2.2.2.2 1000 xe1 2000	Configure VPLS FIB entry for VPLS peer PE-2.
(config)#vpls fib-entry 100 peer 3.3.3.3 3000 xe1 4000	Configure VPLS FIB entry for VPLS peer PE-3.
(config)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode
(config)#interface lo	Enter interface mode
(config-if)#ip address 9.9.9.9/32 secondary	Configure IP address for the loopback interface.
(config-if)#exit	Exit interface mode
(config)#interface xe1	Specify the interface to be configured.
(config-if)#ip address 10.10.1.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode
(config-if)#ip address 20.20.1.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe3	Enter interface mode
(config-if)#ip address 30.30.1.2/24	Configure IP address for the interface.
(config-if)#label-switching	Enable label switching capability on the interface.
(config-if)#exit	Exit interface mode
(config)#router ospf 100	Configure the routing process and specify the routing process ID(100).
(config-router)#ospf router-id 9.9.9.9	Configure OSPF router id same as loopback IP address
(config-router)#transport-address ipv4 9.9.9.9	Configure transport address as loopback address.
(config-router)#network 10.1.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#network 20.20.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#network 30.30.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config-router)#network 9.9.9.9/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the Interface address.
(config)#commit	Commit the transaction.

PE-2

#configure terminal	Enter Configure mode
(config)#mpls ftn-entry tunnel-id 11 1.1.1.1/32 201 20.20.1.2 xe1 primary	Configure MPLS FTN entry for the creation of a static LSP to PE-1, and designate xe1 as primary.

`(config)#mpls ftn-entry tunnel-id 33 3.3.3.3/32 301 20.20.1.2 xe1 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE-3, and designate xe1 as primary.
`(config)#mpls ilm-entry 102 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE-1.
`(config)#mpls ilm-entry 302 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE-3
`(config)#mpls vpls v1 100`	Configure VPLS v1 with ID 100 on PE-2.
`(config-vpls)#vpls-peer 1.1.1.1 tunnel-id 11 manual`	Configure PE-1 as a manual VPLS peer using static LSP tunnel ID
`(config-vpls)#vpls-peer 3.3.3.3 tunnel-id 33 manual`	Configure PE-3 as a manual VPLS peer using static LSP tunnel ID
`(config-vpls)#exit`	Exit Configure VPLS mode
`(config)#interface lo`	Enter interface mode
`(config-if)#ip address 2.2.2.2/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe1`	Enter interface mode
`(config-if)#ip address 20.20.1.1/24`	Configure IP address for the interface
`(config-if)#label-switching`	Configure label switching
`(config-if)#exit`	Exit interface mode
`(config)#service-template st1`	Template configuration
`(config-svc)#exit`	Exit service template mode
`(config)#interface xe2`	Enter interface mode
`(config-if)#switchport`	Make port Layer-2
`(config-if)#mpls-vpls v1 service-template st1`	Bind the VPLS to the Access Interface
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)#exit`	Exit interface mode
`(config)#vpls fib-entry 100 peer 1.1.1.1 2500 xe1 1500`	Configure VPLS FIB entry for VPLS peer PE-1.
`(config)#vpls fib-entry 100 peer 3.3.3.3 3500 xe1 4500`	Configure VPLS FIB entry for VPLS peer PE-3.
`(config)#router ospf 100`	Configure the routing process and specify the routing process ID(100).
`(config-router)#ospf router-id 2.2.2.2`	Configure OSPF router id same as loopback IP address
`(config-router)#transport-address ipv4 2.2.2.2`	Configure transport address as loopback address.
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#network 20.20.1.0/24 area 0`	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
`(config-router)#network 2.2.2.2/32 area 0`	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
`(config-router)#exit`	Exit router mode
`(config)#commit`	Commit the transaction.

PE-3

`#configure terminal`	Enter Configure mode
`(config)#mpls ftn-entry tunnel-id 11 1.1.1.1/32 301 30.30.1.2 xe1 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE-1.
`(config)#mpls ftn-entry tunnel-id 22 2.2.2.2/32 302 30.30.1.2 xe1 primary`	Configure MPLS FTN entry for the creation of a static LSP to PE-2.
`(config)#mpls ilm-entry 103 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE-1.
`(config)#mpls ilm-entry 203 pop`	Configure MPLS ILM entry for the creation of a static LSP to PE-2.
`(config)#mpls vpls v1 100`	Configure VPLS v1 with ID 100 on PE-3.
`(config-vpls)#vpls-peer 1.1.1.1 tunnel-id 11 manual`	Configure PE-1 as a manual VPLS peer using static LSP tunnel ID 11.
`(config-vpls)#vpls-peer 2.2.2.2 tunnel-id 22 manual`	Configure PE-2 as a manual VPLS peer using static LSP tunnel ID 22.
`(config-vpls)#exit`	Exit Configure VPLS mode
`(config)#interface lo`	Enter interface mode
`(config-if)#ip address 3.3.3.3/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe1`	Enter interface mode
`(config-if)#ip address 30.30.1.1/24`	Configure IP address for the interface
`(config-if)#label-switching`	Configure label switching
`(config-if)#exit`	Exit interface mode
`(config)#service-template st1`	Template configuration
`(config-svc)#exit`	Exit service template mode
`(config)#interface xe2`	Enter interface mode
`(config-if)#switchport`	Switch to Layer-2 mode
`(config-if)#mpls-vpls v1 service-template st1`	Bind the VPLS to the Access Interface.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)#exit`	Exit interface mode.
`(config)#vpls fib-entry 100 peer 1.1.1.1 4000 xe1 3000`	Configure VPLS FIB entry for VPLS peer PE-1.
`(config)#vpls fib-entry 100 peer 2.2.2.2 4500 xe1 3500`	Configure VPLS FIB entry for VPLS peer PE-2.
`(config)#router ospf 100`	Configure the routing process and specify the routing process ID(100).
`(config-router)#ospf router-id 3.3.3.3`	Configure OSPF router id same as loopback IP address
`(config-router)#transport-address ipv4 3.3.3.3`	Configure transport address as loopback address.
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode

(config-router)#network 30.30.1.0/24 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config-router)#network 3.3.3.3/32 area 0	Define the interface address on which the OSPF runs and associate an area ID(0) with the interface address.
(config)#commit	Commit the transaction.

Validation

Enter the commands listed in the sections below to confirm the configurations.

Verify VPLS Session on PE-1

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 100
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe48
 Service-template : st1
  Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Up)
   Tunnel-Id: 11
   3.3.3.3 (Up)
   Tunnel-Id: 22
PE1#
```

Verify VPLS Peer

```
#show mpls vpls mesh
VPLS-ID    Peer Addr         Tunnel-Label  In-Label    Network-Intf   Out-Label  Lkps/St    PW-INDEX SIG-Protocol  Status
100        2.2.2.2           102           1000          xe1           2000       2/Up       1          STATIC        Active
100        3.3.3.3           103           3000          xe1           4000       2/Up       2          STATIC        Active
PE1#
```

Remove Configurations

Follow these steps to remove VPLS peer and VPLS spoke FIB entries from router PE-2.

#configure terminal	Enter configure mode
(config)#no vpls fib-entry 100 peer 1.1.1.1	Remove VPLS FIB for VPLS peer PE-1.

`(config)#no vpls fib-entry 100 peer 3.3.3.3`	Remove VPLS FIB for VPLS peer PE-3.
`(config)#exit`	Exit Configure mode

CHAPTER 5 BGP-VPLS Configuration

This chapter contains configurations for VPLS with Border Gateway Protocol Signaling.

Overview

Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP/MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. A set of Kompella circuits is grouped by a common VPLS identifier to achieve this service objective.

A Pseudowire (PW) consists of a pair of point-to-point, single-hop unidirectional LSPs in opposite directions, each identified by a PW label, also called a Virtual Connection (VC) label.

The Border Gateway Protocol (BGP) is used to signaling VCs and for auto-discovery of neighbors. A service provider may use either LDP or RSVP-TE or add static provisioning to set up LSP tunnels to transport data through virtual circuits.

The VPLS identifier is exchanged with the labels, so that both PWs can be linked and associated with a particular VPLS instance.

Note: In Inter-AS, OcNOS accepts information from any other AS but the same VPN-ID/VPLS-ID (*: VPLS-ID). OcNOS does not have explicit RD/RT (import/export) support for BGP VPLS. RD/RT are automatically generated based on the configured BGP AS number and VPN-ID/VPLS-ID as (AS-number: VPN-ID).

Topology

The diagram depicts the topology for the configuration examples that follow.

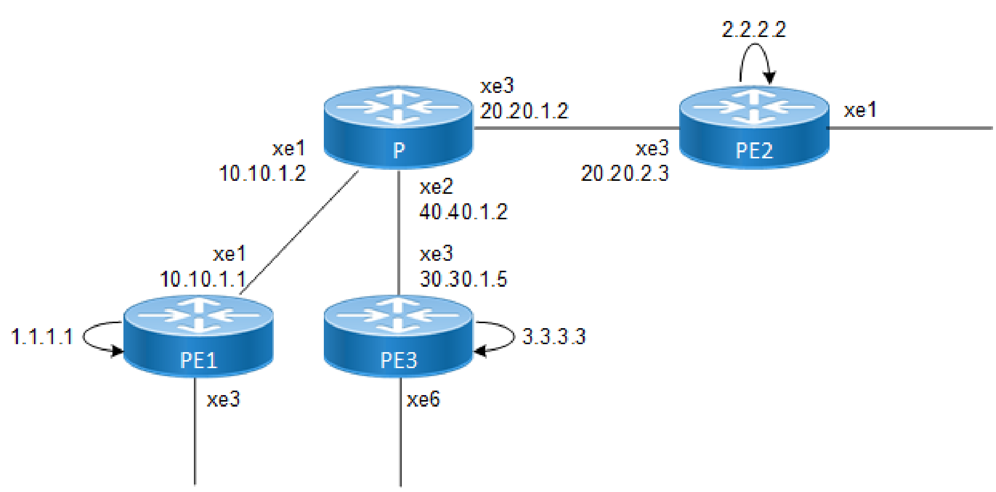

Figure 5-21: Sample Topology for VPLS with BGP Signaling

BGP-VPLS Configuration

PE-1

#configure terminal	Enter configuration mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 10.10.1.1/24	Set the IP address of the interface to 10.10.1.1/24.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#exit	Exit interface mode
(config)#mpls vpls v1 25	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (v1) and VPLS ID (25).
(config-vpls)#vpls-mtu 1400	Configure the MTU for the VPLS. (Default is 1500; range is <576 - 65535>.
(config-vpls)#signaling bgp	Enter the Signaling bgp mode for BGP VPLS.
(config-vpls-sig)#ve-id 1	Configure VE ID, which is mandatory for BGP VPLS, otherwise, Signaling does not take place. VE ID should be unique per VPLS instance.
(config-vpls-sig)#exit	Exit is a mandatory command for signaling BGP configuration to take affect. If exit is not given BGP signaling does not take place.
(config-vpls)#exit	Exit VPLS mode.
(config)#service-template v1	Configure service template
(config-svc)#match all	Configure the match condition
(config-svc)#exit	Exit interface mode
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#switchport	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
(config-if)#mpls-vpls v1 service-template v1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

Note: VE IDs range is from 1 to 64. Administrator should configure the VE ID’s accordingly in their Network.

PE1 - LDP

#configure terminal	Enter configuration mode
(config)#router ldp	Enter Router LDP mode.

(config-router)#router-id 1.1.1.1	Configure the router ID.
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for a label space by binding the address to a loopback address.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#commit	Commit the transaction.

PE1 - OSPF

#configure terminal	Enter configure mode
(config)#router ospf 1	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 10.10.1.0/24 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
(config-router)#network 1.1.1.1/32 area 0	
(config-router)#commit	Commit the transaction.

PE1 - BGP

#configure terminal	Enter configuration mode.
(config)#router bgp 100	Enter BGP Configure mode.
(config-router)#neighbor 2.2.2.2 remote-as 100	Configure PE2 as an iBGP peer.
(config-router)#neighbor 2.2.2.2 update-source lo	Update the source as loopback for iBGP peering with the remote PE2 router.
(config-router)#neighbor 3.3.3.3 remote-as 100	Configure PE3 as an iBGP peer.
(config-router)#neighbor 3.3.3.3 update-source lo	Update the source as loopback for iBGP peering with the remote PE3 router
(config-router)#address-family l2vpn vpls	Configure address-family L2VPN VPLS.
(config-router-af)#neighbor 2.2.2.2 activate	Activate PE2 in the VPLS address family.
(config-router-af)#neighbor 3.3.3.3 activate	Activate PE3 in the VPLS address family.
(config-router-af)#commit	Commit the transaction.

PE2

#configure terminal	Enter configuration mode.
(config)#interface xe3	Specify the interface (xe3 to be configured.
(config-if)#ip address 20.20.1.3/24	Set the IP address of the interface to 20.20.1.3/24.
(config-if)#label-switching	Enable label switching on interface xe3.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback address.

`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to `2.2.2.2/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls vpls v1 25`	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (v1) and VPLS ID (`25`).
`(config-vpls)#vpls-mtu 1400`	Configure the MTU for the VPLS. (Default is 1500; range is <576 - 65535>.)
`(config-vpls)#signaling bgp`	Enter the Signaling BGP mode for BGP VPLS.
`(config-vpls-sig)#ve-id 2`	Configure ve-id, which is mandatory for BGP VPLS. Without a ve-id Signaling does not take place. VE ID should be unique per VPLS instance.
`(config-vpls-sig)#exit`	Exit is a mandatory command for signaling BGP configuration to take affect. If exit is done, BGP signaling does not take place.
`(config-vpls)#exit`	Exit VPLS mode.
`(config)#service-template v1`	Configure service template
`(config-svc)#match all`	Configure the match condition
`(config-svc)#exit`	Exit interface mode
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode. (VPLS can only be bound on the Layer-2 port.)
`(config-if)#mpls-vpls v1 service-template v1`	Bind the VPLS to the Access Interface.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)#commit`	Commit the transaction.

Note: VE ID’s range is from 1 to 64. Administrator should configure the VE ID’s accordingly in their Network.

PE2 - LDP

`#configure terminal`	Enter configuration mode
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#router-id 2.2.2.2`	Configure the router ID.
`(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address for a label space by binding the address to a loopback address.
`(config-router)#exit`	Exit Router mode.
`(config)#interface xe3`	Specify the interface `(xe3)` to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on the specified interface (`xe3`).
`(config-if)#commit`	Commit the transaction.

PE2 - OSPF

`#configure terminal`	Enter configuration mode.
`(config)#router ospf 1`	Configure the OSPF routing process, and specify the process ID.
`(config-router)#network 20.20.1.0/24 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
`(config-router)#network 2.2.2.2/32 area 0`	
`(config-router)#commit`	Commit the transaction.

PE2 - BGP

`#configure terminal`	Enter configuration mode.
`(config)#router bgp 100`	Enter BGP router mode.
`(config-router)#neighbor 1.1.1.1 remote-as 100`	Configure PE1 as an iBGP peer.
`(config-router)#neighbor 1.1.1.1 update-source lo`	Update the source as loopback for iBGP peering with the remote PE1 router.
`(config-router)#neighbor 3.3.3.3 remote-as 100`	Configure PE3 as an iBGP peer.
`(config-router)#neighbor 3.3.3.3 update-source lo`	Update the source as loopback for iBGP peering with the remote PE3 router.
`(config-router)#address-family l2vpn vpls`	Configure address-family L2VPN VPLS.
`(config-router-af)#neighbor 1.1.1.1 activate`	Activate PE1 in the VPLS address family.
`(config-router-af)#neighbor 3.3.3.3 activate`	Activate PE3 in the VPLS address family.
`(config-router-af)#commit`	Commit the transaction.

PE3

`#configure terminal`	Enter configuration mode.
`(config)#interface xe3`	Specify the interface `(xe3)` to be configured.
`(config-if)#ip address 40.40.1.5/24`	Set the IP address of the interface to `40.40.1.5/24`.
`(config-if)#label-switching`	Enable label switching on interface `xe3`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback address.
`(config-if)#ip address 3.3.3.3/32 secondary`	Set the IP address of the loopback interface to `3.3.3.3/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#mpls vpls v1 25`	Create an instance of VPLS, and switch to the VPLS command mode, by indicating the VPLS name (v1) and VPLS ID (`25`).
`(config-vpls)#vpls-mtu 1400`	Configure the MTU for the VPLS. Default is 1500; range is <576 - 65535>.
`(config-vpls)#signaling bgp`	Enter the Signaling BGP mode, for BGP VPLS.

`(config-vpls-sig)#ve-id 3`	Configure ve-id, which is mandatory for BGP VPLS. Without a ve-id Signaling does not take place. VE ID should be unique per VPLS instance
`(config-vpls-sig)#exit`	Exit is a mandatory command for signaling BGP configuration to take affect. If exit is not done, BGP signaling does not take place.
`(config-vpls)#exit`	Exit VPLS mode.
`(config)#service-template v1`	Configure service template
`(config-svc)#match all`	Configure the match condition
`(config-svc)#exit`	Exit interface mode
`(config)#interface xe6`	Specify the interface `(xe6)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
`(config-if)#mpls-vpls v1 service-template v1`	Bind the VPLS to the Access Interface.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config-if-vpls)#exit`	Exit VPLS attachment-circuit mode
`(config-if)#commit`	Commit the transaction.

Note: VE ID’s range is from 1 to 64. Administrator should configure the VE ID’s accordingly in their Network.

PE3 - LDP

`#configure terminal`	Enter configuration mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#router-id 3.3.3.3`	Configure the router ID.
`(config-router)#transport-address ipv4 3.3.3.3`	Configure the transport address for a label space by binding the address to a loopback address.
`(config-router)#exit`	Exit Router mode.
`(config)#interface xe3`	Specify the interface `(xe3)` to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)#commit`	Commit the transaction.

PE3 - OSPF

`#configure terminal`	Enter configuration mode.
`(config)#router ospf 1`	Configure the OSPF routing process, and specify the process ID.
`(config-router)#network 40.40.1.0/24 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
`(config-router)#network 3.3.3.3/32 area 0`	
`(config-router)#commit`	Commit the transaction.

PE3 - BGP

`#configure terminal`	Enter configuration mode.
`(config)#router bgp 100`	Enter BGP Router mode.
`(config-router)#neighbor 1.1.1.1 remote-as 100`	Configure PE1 as an iBGP peer.
`(config-router)#neighbor 1.1.1.1 update-source lo`	Update the source as loopback for iBGP peering with the remote PE1 router.
`(config-router)#neighbor 2.2.2.2 remote-as 100`	Configure PE2 as an iBGP peer.
`(config-router)#neighbor 2.2.2.2 update-source lo`	Update the source as loopback for iBGP peering with the remote PE2 router.
`(config-router)#address-family l2vpn vpls`	Configure address-family L2VPN VPLS.
`(config-router-af)#neighbor 1.1.1.1 activate`	Activate PE1 in the VPLS address family.
`(config-router-af)#neighbor 2.2.2.2 activate`	Activate PE2 in the VPLS address family.
`(config-router-af)#commit`	Commit the transaction.

P

`#configure terminal`	Enter configuration mode.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 10.10.1.2/24`	Set the IP address of the interface to `10.10.1.2/24`.
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Specify the interface `(xe2)` to be configured.
`(config-if)#ip address 40.40.1.2/24`	Set the IP address of the interface to `40.40.1.2/24`.
`(config-if)#label-switching`	Enable label switching on interface `xe2`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe3`	Specify the interface `(xe3)` to be configured.
`(config-if)#ip address 20.20.1.2/24`	Set the IP address of the loopback interface to `20.20.1.2/24`.
`(config-if)#label-switching`	Enable label switching on interface `xe3`.
`(config-if)#commit`	Commit the transaction.

P - LDP

`#configure terminal`	Enter configuration mode.
`(config)#router ldp`	Enter Router LDP mode.
`(config-router)#exit`	Exit Router mode.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#enable-ldp ipv4`	Enable LDP on the interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on the interface.
(config-if)#commit	Commit the transaction.

P - OSPF

#configure terminal	Enter configuration mode.
(config)#router ospf 1	Configure the OSPF routing process, and specify the process ID.
(config-router)#network 10.10.1.0/24 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
(config-router)#network 20.20.1.0/24 area 0	
(config-router)#network 40.40.1.0/24 area 0	
(config-router)#commit	Commit the transaction.

Note: BGP L2VPN VPLS Route Reflector is not supported.

Validation

PE1

```
#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
  Route-Distinguisher :100:25
  Route-Target :100:25
  VE-ID :1
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, Configured MTU: 1400
 Description: none
 Redundancy admin role: Primary  Redundancy oper role: Primary
 Configured interfaces:   Interface: xe3      oper-state UP  Service-template
: v1  Match criteria : Accept all

 Mesh Peers:
   2.2.2.2 (Up)
   3.3.3.3 (Up)

#show mpls vpls mesh
VPLS-ID    Peer Addr    Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol  Status   Ecmp-Group
25      2.2.2.2     3             24969     xe1            26125     2/Up
1298      BGP           Active      N/A
25      3.3.3.3     24677         24961     xe1            25605     2/Up
1297      BGP           Active      N/A

#show bgp l2vpn vpls detail
```

```
VPLS ID: 25
VE-ID: 1
Discovered Peers: 2
Route-Target: 1:100
Local RD: 2:100
 Mesh Peers:
  Address:2.2.2.2, RD:2:100, VE-ID:2
  VC Details: VC-ID:610
  Remote (LB:26120,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:24969, Out Label:26125
  PW Status:Established
  VC Installed:Yes
 All Local LB:
  LB:24960,VBO:1,VBS:64

  Address:3.3.3.3, RD:2:100, VE-ID:3
  VC Details: VC-ID:62
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:24961, Out Label:25605
  PW Status:Established
  VC Installed:Yes

 #show bgp l2vpn vpls 25
 VPLS ID: 25
 VE-ID: 1
 Discovered Peers: 2
 Route-Target: 1:100
 Local RD: 2:100
  Mesh Peers:
   Address:2.2.2.2, RD:2:100, VE-ID:2
   VC Details: VC-ID:610
   Remote (LB:26120,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
   LB sent on known VEID:Yes
   In Label:24969, Out Label:26125
   PW Status:Established
   VC Installed:Yes
  All Local LB:
  LB:24960,VBO:1,VBS:64

  Address:3.3.3.3, RD:2:100, VE-ID:3
  VC Details: VC-ID:62
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:24960,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:24961, Out Label:25605
  PW Status:Established
  VC Installed:Yes
```

PE2

```
PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol  Status
```

```
25        1.1.1.1          25601          25600     xe3           25601
2/Up      1         BGP           Active
25        3.3.3.3          25602          25602     xe3           25601
2/Up      2         BGP           Active


PE2#show ldp sess
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
10.10.1.2                 xe3        Passive   OPERATIONAL   30    00:15:54

PE2#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
  Route-Distinguisher :100:25
  Route-Target :100:25
  VE-ID :2
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1400
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe1
 Service-template : v1
  Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Up)
   3.3.3.3 (Up)


PE2#show bgp l2vpn vpls detail

VPLS ID: 25
VE-ID: 2
Discovered Peers: 2
Route-Target: 100:25
Local RD: 100:25
 Mesh Peers:
 BGP Peer:1.1.1.1/32
  VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25600, Out Label:25601
  PW Status:Established
  VC Installed:Yes

 BGP Peer:3.3.3.3/32
  VC Nbr Address:3.3.3.3, RD:100:25, VE-ID:3
  VC Details: VC-ID:23
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25602, Out Label:25601
```

```
    PW Status:Established
    VC Installed:Yes

PE2#show bgp l2vpn vpls 25

VPLS ID: 25
VE-ID: 2
Discovered Peers: 2
Route-Target: 100:25
Local RD: 100:25
 Mesh Peers:
 BGP Peer:1.1.1.1/32
  VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25600, Out Label:25601
  PW Status:Established
  VC Installed:Yes

 BGP Peer:3.3.3.3/32
  VC Nbr Address:3.3.3.3, RD:100:25, VE-ID:3
  VC Details: VC-ID:23
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25602, Out Label:25601
  PW Status:Established
  VC Installed:Yes
```

P

```
P#show ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
3.3.3.3                   xe2        Active    OPERATIONAL   30    00:11:21
2.2.2.2                   xe3       Active    OPERATIONAL   30    00:19:05
1.1.1.1                   xe1        Active    OPERATIONAL   30    00:51:45
```

PE3

```
PE3#show ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
10.10.1.2                 xe3        Passive   OPERATIONAL   30    00:12:27

PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol  Status
25         1.1.1.1          25604         25600      xe3            25602
2/Up      1         BGP           Active
25         2.2.2.2          25605         25601      xe3            25602
2/Up      2         BGP           Active

PE3#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
  Route-Distinguisher :100:25
  Route-Target :100:25
```

```
  VE-ID :3
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1400
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe6
 Service-template : v1
  Match criteria : Accept all

 Mesh Peers:
   1.1.1.1 (Up)
   2.2.2.2 (Up)


PE3#show bgp l2vpn vpls detail

VPLS ID: 25
VE-ID: 3
Discovered Peers: 2
Route-Target: 100:25
Local RD: 100:25
 Mesh Peers:
 BGP Peer:1.1.1.1/32
  VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1
  VC Details: VC-ID:31
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25600, Out Label:25602
  PW Status:Established
  VC Installed:Yes
 All Local LB:
  LB:25600,VBO:1,VBS:64

 BGP Peer:2.2.2.2/32
  VC Nbr Address:2.2.2.2, RD:100:25, VE-ID:2
  VC Details: VC-ID:32
  Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25601, Out Label:25602
  PW Status:Established
  VC Installed:Yes
 All Local LB:
  LB:25600,VBO:1,VBS:64

PE3#show bgp l2vpn vpls 25

VPLS ID: 25
VE-ID: 3
Discovered Peers: 2
Route-Target: 100:25
Local RD: 100:25
 Mesh Peers:
```

```
BGP Peer:1.1.1.1/32
 VC Nbr Address:1.1.1.1, RD:100:25, VE-ID:1
 VC Details: VC-ID:31
 Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
 LB sent on known VEID:Yes
 In Label:25600, Out Label:25602
 PW Status:Established
 VC Installed:Yes
All Local LB:
 LB:25600,VBO:1,VBS:64

BGP Peer:2.2.2.2/32
 VC Nbr Address:2.2.2.2, RD:100:25, VE-ID:2
 VC Details: VC-ID:32
 Remote (LB:25600,VBO:1,VBS:64)  Local (LB:25600,VBO:1,VBS:64)
 LB sent on known VEID:Yes
 In Label:25601, Out Label:25602
 PW Status:Established
 VC Installed:Yes
All Local LB:
 LB:25600,VBO:1,VBS:64
```

CHAPTER 6 Static VPLS Service Mapping Configuration

Overview

This chapter includes step-by-step configurations for static VPLS. It also contains an overview of the concepts of Static VPLS. Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP- MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires.

Topology

The diagram depicts the topology for the configuration examples that follow.

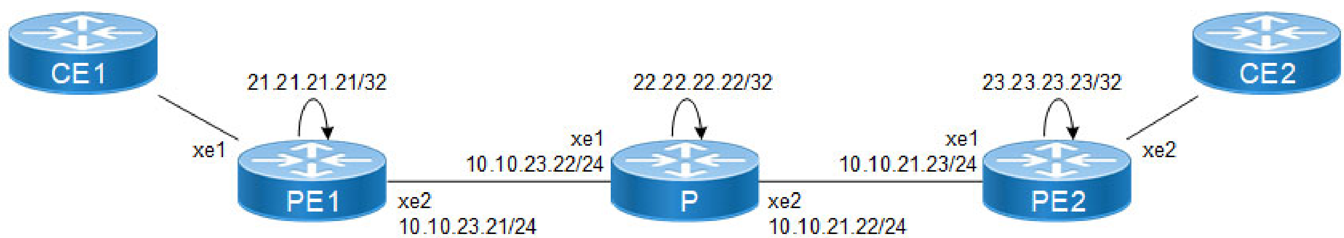

Figure 6-22: Static VPLS service mapping

Configuration

PE1: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter interface mode for the loopback interface.
`(config-if)#ip address 21.21.21.21/32 secondary`	Configure IP address on loopback interface.
`(config-if)#commit`	Commit the candidate configuration to the running configuration.
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 21.21.21.21`	Set the router ID to IP address 21.21.21.21
`(config-router)#transport-address ipv4 21.21.21.21`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 23.23.23.23`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode

PE1: Interface Configuration

`(config)#interface xe2`	Enter interface mode for xe2.
`(config-if)#ip address 10.10.23.21/24`	Configure IP address on the interface.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on xe2
`(config-if)#commit`	Commit the candidate configuration to the running configuration.
`(config-if)#exit`	Exit interface mode

PE1: Static VPLS Configuration

`(config)#mpls vpls v1 25`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#exit`	Exit from VPLS configuration mode
`(config)#mpls vpls v2 26`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#exit`	Exit from VPLS configuration mode
`(config)#mpls vpls v3 27`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#exit`	Exit from VPLS configuration and configuration mode
`(config)#mpls vpls v4 28`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 23.23.23.23 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#commit`	Commit the candidate configuration to the running configuration.
`(config-vpls)#end`	Exit from VPLS configuration and configuration mode

PE1: FIB Entry Configuration

`#configure terminal`	Enter configuration mode.
`(config)#mpls ftn-entry tunnel-id 1 23.23.23.23/32 100 10.10.23.22 xe2 primary`	Configure Static LSP FTN entry
`(config)#mpls ilm-entry 250 pop`	Configure ILM entry
`(config)#commit`	Commit the candidate configuration to the running configuration.
`(config)#exit`	Exit

P: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter interface mode for the loopback interface.

`(config-if)#ip address 22.22.22.22/32 secondary`	Configure IP address on loopback interface.
`(config-if)#commit`	Commit the candidate configuration to the running configuration.
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 22.22.22.22`	Set the router ID to IP address 22.22.22.22
`(config-router)#transport-address ipv4 22.22.22.22`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode

P: Interface Configuration

`(config)#interface xe1`	Enter interface mode for xe1.
`(config-if)#ip address 10.10.23.22/24`	Configure IP address on the interface.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#commit`	Commit the candidate configuration to the running configuration.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode for xe2.
`(config-if)#ip address 10.10.21.22/24`	Configure IP address on the interface.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#commit`	Commit the candidate configuration to the running configuration.
`(config-if)#exit`	Exit interface mode

P: FIB Entry Configuration

`#configure terminal`	Enter configure mode.
`(config)#mpls ilm-entry 100 swap 200 xe2 10.10.21.23 23.23.23.23/32`	Configure Static LSP ILM entry
`(config)#mpls ilm-entry 150 swap 250 xe1 10.10.23.21 21.21.21.21/32`	Configure ILM entry
`(config)#commit`	Commit the candidate configuration to the running configuration.
`(config)#exit`	Exit

PE2: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter interface mode for the loopback interface.
`(config-if)#ip address 23.23.23.23/32 secondary`	Configure IP address on loopback interface.

`(config-if)#commit`	Commit the candidate configuration to the running configuration.
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 23.23.23.23`	Set the router ID to IP address 23.23.23.23
`(config-router)#transport-address ipv4 23.23.23.23`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 21.21.21.21`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode

PE2: Interface Configuration

`(config)#interface xe1`	Enter interface mode for xe1.
`(config-if)#ip address 10.10.21.23/24`	Configure IP address on the interface.
`(config-if)#label-switching`	Enable label switching on the interface.
`(config-if)#commit`	Commit the candidate configuration to the running configuration.
`(config-if)#exit`	Exit interface mode

PE2: Static VPLS Configuration

`(config)#mpls vpls v1 25`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#exit`	Exit from VPLS configuration mode
`(config)#mpls vpls v2 26`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#exit`	Exit from VPLS configuration mode
`(config)#mpls vpls v3 27`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#exit`	Exit from VPLS configuration and configuration mode
`(config)#mpls vpls v4 28`	Enter VPLS configuration mode
`(config-vpls)#vpls-peer 21.21.21.21 tunnel-id 1 manual`	Configure VPLS peer
`(config-vpls)#commit`	Commit the candidate configuration to the running configuration.
`(config-vpls)#exit`	Exit from VPLS configuration and configuration mode

PE2: FIB Entry Configuration

(config)#mpls ftn-entry tunnel-id 1 21.21.21.21/32 150 10.10.21.22 xe1	Configure Static LSP FTN entry
(config)#mpls ilm-entry 200 pop	Configure ILM entry
(config)#commit	Commit the candidate configuration to the running configuration.
(config)#exit	Exit

Static VPLS Service Mapping Configuration

PE1: POP

#configure terminal	Enter configuration mode.
(config)#service-template template1	Template configuration
(config-svc)#match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)#rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE1: XLATE

(config)#service-template template2	Template configuration
(config-svc)#match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)#rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH

(config)#service-template template3	Template configuration
(config-svc)#match outer-vlan 500	Match criteria under template configuration
(config-svc)#rewrite ingress push 300	Action to be performed for the default match .
(config-svc)#commit	Commit the candidate configuration to the running configuration.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH-service-template with multiple match support

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

`(config)#service-template template4`	Template configuration
`(config-svc)# match outer-vlan 700`	Allow VLAN 700 traffic on this VC
`(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200`	Allow double tag match with s+c tags
`(config-svc)# match untagged`	Allow untagged traffic
`(config-svc)# rewrite ingress push 300`	Push Action performed for service template
`(config-svc)#commit`	Commit the candidate configuration to the running configuration.
`(config-svc)#exit`	Exit configure SVC mode

PE1: Access port Configuration

`(config)#interface xe1`	Enter the Interface mode for ethernet1.
`(config-if)#switchport`	Configure interface as L2 interface
`(config-if)#mpls-vpls v1 service-template template1`	Configure template configuration.
`(config_if_vpls)#exit`	Exit Interface VPLS mode and return to Interface mode.
`(config-if)#mpls-vpls v2 service-template template2`	Configure template configuration.
`(config_if_vpls)#exit`	Exit Interface VPLS mode and return to Interface mode.
`(config-if)#mpls-vpls v3 service-template template3`	Configure template configuration.
`(config_if_vpls)#exit`	Exit Interface VPLS mode and return to Interface mode.
`(config-if)#mpls-vpls v4 service-template template4`	Configure template configuration.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config_if_vpls)#exit`	Exit Interface mode and return to Configure mode.
`(config_if)#exit`	Exit interface mode.
`(config)#vpls fib-entry 25 peer 23.23.23.23 1001 xe2 2001`	Configure access port
`(config)#vpls fib-entry 26 peer 23.23.23.23 1002 xe2 2002`	Configure access port
`(config)#vpls fib-entry 27 peer 23.23.23.23 1003 xe2 2003`	Configure access port
`(config)#vpls fib-entry 28 peer 23.23.23.23 1004 xe2 2004`	Configure access port
`(config)#commit`	Commit the candidate configuration to the running configuration.

PE2: POP

`#configure terminal`	Configure mode
`(config)#service-template template1`	Template configuration
`(config-svc)#match double-tag outer-vlan 2024 inner-vlan 2023`	Match criteria under template configuration
`(config-svc)#rewrite ingress pop outgoing-tpid dot1.q`	Action to be performed for the match.
`(config-svc)#commit`	Commit the candidate configuration to the running configuration.
`(config-svc)#exit`	Exit template configuration mode

PE2: XLATE

`(config)#service-template template2`	Template configuration
`(config-svc)#match double-tag outer-vlan 2030 inner-vlan 2024`	Match criteria under template configuration
`(config-svc)#rewrite ingress translate 2026 outgoing-tpid dot1.q`	Action to be performed for the match
`(config-svc)#commit`	Commit the candidate configuration to the running configuration.
`(config-svc)#exit`	Exit template configuration mode

PE2: PUSH

`(config)#service-template template3`	Template configuration
`(config-svc)#match outer-vlan 500`	Match criteria under template configuration
`(config-svc)#rewrite ingress push 300`	Action to be performed for the default match.
`(config-svc)#commit`	Commit the candidate configuration to the running configuration.
`(config-svc)#exit`	Exit template configuration mode

PE2: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

`(config)#service-template template4`	Template configuration
`(config-svc)# match outer-vlan 700`	Allow VLAN 700 traffic on this VC
`(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200`	Allow double tag match with s+c tags
`(config-svc)# match untagged`	Allow untagged traffic
`(config-svc)# rewrite ingress push 300`	Push Action performed for service template
`(config-svc)#commit`	Commit the candidate configuration to the running configuration.
`(config-svc)#exit`	Exit configure SVC mode

PE2: Access port Configuration

`(config)#interface xe2`	Enter the Interface mode for ethernet2.
`(config-if)#switchport`	Configure interface as L2 interface
`(config-if)#mpls-vpls v1 service-template template1`	Configure template configuration.
`(config_if_vpls)#exit`	Exit Interface VPLS mode and return to Interface mode.
`(config-if)#mpls-vpls v2 service-template template2`	Configure template configuration.
`(config_if_vpls)#exit`	Exit Interface VPLS mode and return to Interface mode.
`(config-if)#mpls-vpls v3 service-template template3`	Configure template configuration.
`(config_if_vpls)#exit`	Exit Interface VPLS mode and return to Interface mode.
`(config-if)#mpls-vpls v4 service-template template4`	Configure template configuration.
`(config-if-vpls)#split-horizon group access1`	Configure split-horizon group on VPLS
`(config_if_vpls)#exit`	Exit Interface VPLS mode and return to Interface mode.
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#vpls fib-entry 25 peer 21.21.21.21 2001 xe1 1001`	Configure access port
`(config)#vpls fib-entry 26 peer 21.21.21.21 2002 xe1 1002`	Configure access port
`(config)#vpls fib-entry 27 peer 21.21.21.21 2003 xe1 1003`	Configure access port
`(config)#vpls fib-entry 28 peer 21.21.21.21 2004 xe1 1004`	Configure access port
`(config)#commit`	Commit the candidate configuration to the running configuration.

Validation

```
#show mpls vpls mesh
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX  SIG-Protocol  Status   Ecmp-Group
25         23.23.23.23       150            1001       xe2            2001
2/Up      1         STATIC        Active   N/A
26         23.23.23.23       150            1002       xe2            2002
2/Up      2         STATIC        Active   N/A
27         23.23.23.23       150            1003       xe2            2003
2/Up      3         STATIC        Active   N/A
28         23.23.23.23       150            1004       xe2            2004
2/Up      4         STATIC        Active   N/A


#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, Configured MTU: 1500
 Description: none
```

```
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe1
 Service-template : template1
  Match criteria : 2024/2023
  Action type : Pop
  Outgoing tpid : dot1.q

 Mesh Peers:
   23.23.23.23 (Up)


Virtual Private LAN Service Instance: v2, ID: 26
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe1
 Service-template : template2
  Match criteria : 2030/2024
  Action type : Translate
  Action value : 2026
  Outgoing tpid : dot1.q

 Mesh Peers:
   23.23.23.23 (Up)


Virtual Private LAN Service Instance: v3, ID: 27
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe1
 Service-template : template3
  Match criteria : Accept all
  Action type : Push
  Action value : 300

 Mesh Peers:
   23.23.23.23 (Up)

Virtual Private LAN Service Instance: v4, ID: 28
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, Configured MTU: 1500
 Description: none
```

```
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe1
Service-template : template4
  Match criteria : 700
 1200/3200
 Untagged
  Action type : Push
  Action value : 300

 Mesh Peers:
   23.23.23.23 (Up)

PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol  Status
25         21.21.21.21      150           2001       xe10           1001
2/Up      1         STATIC        Active
26         21.21.21.21      150           2002       xe10           1002
2/Up      2         STATIC        Active
27         21.21.21.21      150           2003       xe10           1003
2/Up      3         STATIC        Active
28         21.21.21.21      150           2004       xe10           1004
2/Up      4         STATIC        Active

PE2#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe45
 Service-template : template1
  Match criteria : 2024/2023
  Action type : Pop
  Outgoing tpid : dot1.q

 Mesh Peers:
   21.21.21.21 (Up)
   Tunnel-Id: 1


Virtual Private LAN Service Instance: v2, ID: 26
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
```

```
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe45
 Service-template : template2
  Match criteria : 2030/2024
  Action type : Translate
  Action value : 2026
  Outgoing tpid : dot1.q

 Mesh Peers:
   21.21.21.21 (Up)
   Tunnel-Id: 1


Virtual Private LAN Service Instance: v3, ID: 27
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe45
 Service-template : template3
  Match criteria : 500
  Action type : Push
  Action value : 300

 Mesh Peers:
   21.21.21.21 (Up)
   Tunnel-Id: 1


Virtual Private LAN Service Instance: v4, ID: 28
 SIG-Protocol: STATIC
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe45
 Service-template : template4
  Match criteria : 700,
 Untagged ,
 1200/3200
  Action type : Push
  Action value : 300
```

```
 Mesh Peers:
   21.21.21.21 (Up)
   Tunnel-Id: 1

PE2#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
22.22.22.22              xe10       Active    OPERATIONAL   30    00:29:22
21.21.21.21              xe10       Active    OPERATIONAL   30    00:29:26
PE2#

P1#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
21.21.21.21              xe4        Active    OPERATIONAL   30    00:32:31
23.23.23.23              xe10        Passive   OPERATIONAL   30    00:31:47
```

CHAPTER 7 LDP-VPLS Service Mapping Configuration

Overview

This chapter includes step-by-step configurations for LDP VPLS. It also contains an overview of the concepts of LDP VPLS. Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP- MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires.

Topology

The diagram depicts the topology for the configuration examples that follow.

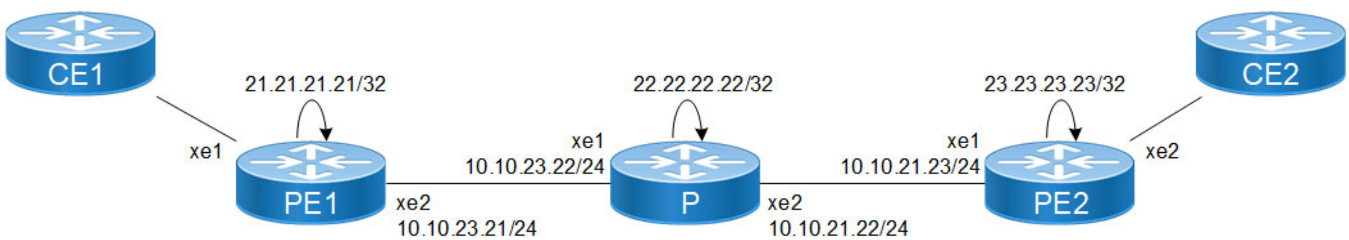

Figure 7-23: LDP-VPLS service mapping

Configuration

PE1: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 21.21.21.21/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

PE1: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 21.21.21.21`	Set the router ID to IP address 21.21.21.21
`(config-router)#transport-address ipv4 21.21.21.21`	Configure transport address
`(config-router)#targeted-peer ipv4 23.23.23.23`	Configure targeted peer
`(config-router)#targeted-peer #commit`	Commit candidate configuration to the running configuration
`(config-router-targeted-peer)#end`	Exit from router target peer and LDP mode

PE1: Interface Configuration

`#configure terminal`	Enter configuration mode
`(config)#interface xe2`	Enter the Interface mode for xe2.
`(config-if)# ip address 10.10.23.21/24`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)# label-switching`	Enable label switching on the interface.
`(config-if)#exit`	Exit interface mode

PE1: OSPF Configuration

`(config)#router ospf 100`	Enter the Router OSPF mode.
`(config-router)#ospf router-id 21.21.21.21`	Router-id configurations
`(config-router)#network 21.21.21.21/32 area 0`	Advertise loopback address in OSPF.
`(config-router)#network 10.10.23.0/24 area 0`	Advertise network address in OSPF.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.

PE1: LDP VPLS Configuration

`(config)#mpls vpls v1 25`	Enter VPLS config mode
`(config-vpls)#service-tpid dot1.ad`	Service tp-id configuration.
`(config-vpls)#signaling ldp`	Define Signaling as LDP
`(config-vpls-sig)#vpls-type vlan`	Type VLAN configuration for VPLS
`(config-vpls-sig)#vpls-peer 23.23.23.23`	Configure VPLS Peer
`(config-vpls-sig)#exit-signaling`	Exit Signaling LDP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#mpls vpls v2 26`	Enter VPLS config mode
`(config-vpls)#service-tpid dot1.ad`	Service tp-id configuration.
`(config-vpls)#signaling ldp`	Define Signaling as LDP
`(config-vpls-sig)#vpls-type vlan`	Type VLAN configuration for VPLS
`(config-vpls-sig)#vpls-peer 23.23.23.23`	Configure VPLS Peer
`(config-vpls-sig)#exit-signaling`	Exit Signaling LDP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#mpls vpls v3 27`	Enter VPLS config mode
`(config-vpls)#signaling ldp`	Define Signaling as LDP
`(config-vpls-sig)#vpls-type vlan`	Type VLAN configuration for VPLS
`(config-vpls-sig)#vpls-peer 23.23.23.23`	Configure VPLS Peer
`(config-vpls-sig)# exit-signaling`	Exit Signaling LDP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#mpls vpls v4 28`	Enter VPLS config mode
`(config-vpls)#signaling ldp`	Define Signaling as LDP
`(config-vpls-sig)#vpls-type vlan`	Type VLAN configuration for VPLS

(config-vpls-sig)#vpls-peer 23.23.23.23	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#commit	Commit candidate configuration to the running configuration

P: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

P: Global LDP

(config)#router ldp	Enter the Router LDP mode.
(config-router)#router-id 22.22.22.22	Set the router ID to IP address 22.22.22.22
(config-router)#transport-address ipv4 22.22.22.22	Configure transport address
(config-router)#commit	Commit candidate configuration to the running configuration
(config-router-targeted-peer)#end	Exit from router target peer and LDP mode

P: Interface Configuration

#configure terminal	Enter configuration mode
(config)#interface xe1	Enter the Interface mode for xe1.
(config-if)# ip address 10.10.23.22/24	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)# ip address 10.10.21.22/24	Configure IP address on the interface.
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 22.22.22.22/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.23.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 10.10.21.0/24 area 0	Advertise network address in OSPF.

`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.
`(config)#commit`	Commit candidate configuration to the running configuration

PE2: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 23.23.23.23/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

PE2: Global LDP

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)#router-id 23.23.23.23`	Set the router ID to IP address 23.23.23.23
`(config-router)#transport-address ipv4 23.23.23.23`	Configure transport address
`(config-router)#targeted-peer ipv4 21.21.21.21`	Configure targeted peer
`(config-router-targeted-peer)#commit`	Commit candidate configuration to the running configuration
`(config-router-targeted-peer)#end`	Exit from router target peer and LDP mode

PE2: Interface Configuration

`#configure terminal`	Enter configuration mode.
`(config)#interface xe1`	Enter the Interface mode for xe1.
`(config-if)# ip address 10.10.21.23/24`	Configure IP address on the interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)# label-switching`	Enable label switching on the interface.
`(config-if)#exit`	Exit interface mode

PE2: OSPF Configuration

`(config)#router ospf 100`	Enter the Router OSPF mode.
`(config-router)#network 23.23.23.23/32 area 0`	Advertise loopback address in OSPF.
`(config-router)#network 10.10.21.0/24 area 0`	Advertise network address in OSPF.
`(config-router)#exit`	Exit Router OSPF mode and return to Configure mode.

PE2: LDP VPLS Configuration

`(config)#mpls vpls v1 25`	Enter VPLS config mode
`(config-vpls)#service-tpid dot1.ad`	Service tp-id configuration.
`(config-vpls)#signaling ldp`	Define Signaling as LDP

(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode
(config-vpls)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling ldp	Define Signaling as LDP
(config-vpls-sig)#vpls-type vlan	Type VLAN configuration for VPLS
(config-vpls-sig)#vpls-peer 21.21.21.21	Configure VPLS Peer
(config-vpls-sig)# exit-signaling	Exit Signaling LDP mode
(config-vpls)#exit	Exit VPLS mode
(config)#commit	Commit candidate configuration to the running configuration

LDP VPLS Service Mapping Configuration

PE1: POP

#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode

PE1: XLATE

(config)#service-template template2	Template configuration
(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#exit	Exit template configuration mode

PE1: PUSH

(config)#service-template template3	Template configuration
(config-svc)# match outer-vlan 500	Match criteria under template configuration
(config-svc)# rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH-service-template with multiple match support

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode

PE1: Access port Configuration

(config)#interface xe1	Enter the Interface mode for xe1.
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode

`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#commit`	Commit candidate configuration to the running configuration

PE2: POP

`#configure terminal`	Configure mode
`(config)#service-template template1`	Template configuration
`(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023`	Match criteria under template configuration
`(config-svc)# rewrite ingress pop outgoing-tpid dot1.q`	Action to be performed for the match.
`(config-svc)#exit`	Exit template configuration mode

PE2: XLATE

`(config)#service-template template2`	Template configuration
`(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024`	Match criteria under template configuration
`(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q`	Action to be performed for the match
`(config-svc)#exit`	Exit template configuration mode

PE2: PUSH

`(config)#service-template template3`	Template configuration
`(config-svc)# match outer-vlan 500`	Match criteria under template configuration
`(config-svc)# rewrite ingress push 300`	Action to be performed for the default match.
`(config-svc)#exit`	Exit template configuration mode

PE2: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

`(config)#service-template template4`	Template configuration
`(config-svc)# match outer-vlan 700`	Allow VLAN 700 traffic on this VC
`(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200`	Allow double tag match with s+c tags
`(config-svc)# match untagged`	Allow untagged traffic
`(config-svc)# rewrite ingress push 300`	Push Action performed for service template
`(config-svc)#exit`	Exit configure SVC mode

PE2: Access port Configuration

(config)#interface xe2	Enter the Interface mode for xe2.
(config-if)#switchport	Configure interface as a layer 2 port.
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#commit	Commit candidate configuration to the running configuration

Validation

```
show mpls vpls mesh
VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol  Status   Ecmp-Group
25         23.23.23.23       24320         24322      xe2            24320
2/Up      1          LDP          Active      N/A
26         23.23.23.23       24320         24320      xe2            24321
2/Up      2          LDP          Active      N/A
27         23.23.23.23       24320         24321      xe2            24322
2/Up      3          LDP          Active      N/A
28         23.23.23.23       24320         24323      xe2            24324
2/Up      3          LDP          Active    N/A

#show ldp vpls
VPLS-ID      Peer Address      State  Type       Label-Sent    Label-Rcvd
25           23.23.23.23       Up     vlan       24322         24320
26           23.23.23.23       Up     vlan       24320         24321
27           23.23.23.23       Up     vlan       24321         24322
28           23.23.23.23       Up     vlan       24323         24324

#show ldp vpls detail
 VPLS Identifier    : 25
 Peer IP            : 23.23.23.23
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 24322
 VC Label Received  : 24320
```

```
 VPLS Identifier    : 26
 Peer IP            : 23.23.23.23
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 24320
 VC Label Received  : 24321

 VPLS Identifier    : 27
 Peer IP            : 23.23.23.23
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 24321
 VC Label Received  : 24322

VPLS Identifier    : 28
 Peer IP            : 23.23.23.23
 VC State           : UP
 VC Type            : vlan
 VC Label Sent      : 24323
 VC Label Received  : 24324

#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.ad
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 88a8
 Configured interfaces:
  Interface: xe1
 Service-template : template1
  Match criteria : 2024/2023

 Mesh Peers:
   23.23.23.23 (Up)


Virtual Private LAN Service Instance: v2, ID: 26
 SIG-Protocol: LDP
 Attachment-Circuit :UP
 Learning: Enabled
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
 Description: none
 service-tpid: dot1.ad
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 88a8
 Configured interfaces:
  Interface: xe1
 Service-template : template2
  Match criteria : 2030/2024
  Action type : Translate
  Action value : 2026
```

```
    Outgoing tpid : dot1.q

   Mesh Peers:
     23.23.23.23 (Up)


  Virtual Private LAN Service Instance: v3, ID: 27
   SIG-Protocol: LDP
   Attachment-Circuit :UP
   Learning: Enabled
   Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
   Description: none
   service-tpid: dot1.q
   Operating mode: Tagged
   Svlan Id: 0
   Svlan Tpid: 8100
   Configured interfaces:
    Interface: xe1
   Service-template : template3
    Match criteria : Accept all
    Action type : Push
    Action value : 300

   Mesh Peers:
     23.23.23.23 (Up)

  Virtual Private LAN Service Instance: v4, ID: 28
   SIG-Protocol: LDP
   Attachment-Circuit :UP
   Learning: Enabled
   Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
   Description: none
   service-tpid: dot1.q
   Operating mode: Tagged
   Svlan Id: 0
   Svlan Tpid: 8100
   Configured interfaces:
    Interface: xe1
   Service-template : template4
   Match criteria : 700
   1200/3200
   Untagged
    Action type : Push
    Action value : 300


   Mesh Peers:
     23.23.23.23 (Up)
```

CHAPTER 8 BGP-VPLS Service Mapping Configuration

Overview

This chapter includes step-by-step configurations for BGP VPLS. It also contains an overview of the concepts of BGP VPLS. Virtual Private LAN Service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP- MPLS networks. It allows geographically-dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires

Topology

The diagram depicts the topology for the configuration examples that follow.

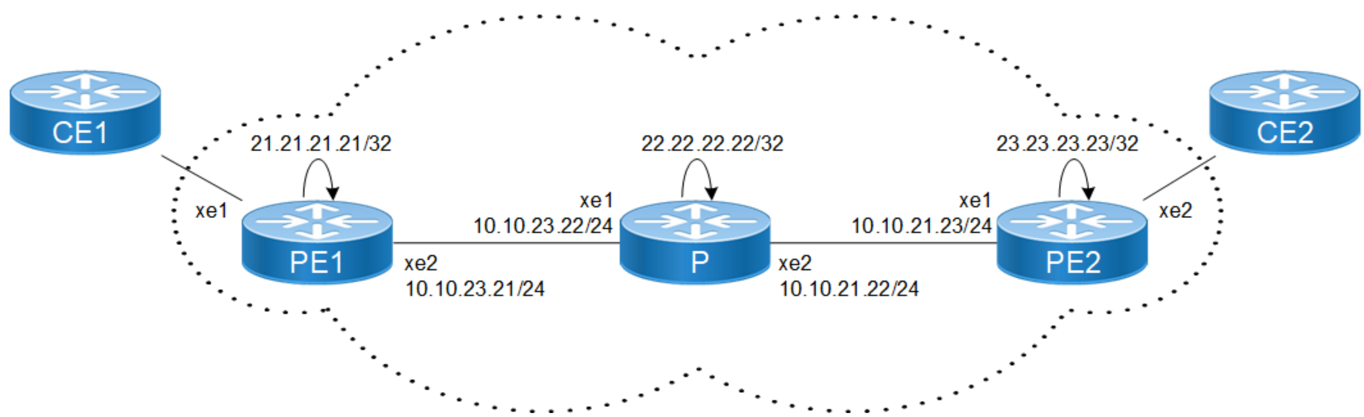

Figure 8-24: BGP-VPLS service mapping

Configuration

PE1: Loopback Interface

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Enter the Interface mode for the loopback interface.
`(config-if)#ip address 21.21.21.21/32 secondary`	Configure IP address on loopback interface.
`(config-if)#exit`	Exit interface mode

PE1: Interface Configuration

`(config)#interface xe2`	Enter the Interface mode for xe2.
`(config-if)# ip address 10.10.23.21/24`	Configure IP address on the interface.
`(config-if)#enable-rsvp`	Enable RSVP on the physical interface

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(config-if)# label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

PE1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#ospf router-id 21.21.21.21	Router-id configurations
(config-router)#network 21.21.21.21/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.23.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE1: Global RSVP

(config)#router rsvp	Enter the Router OSPF mode.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.

PE1: RSVP-Trunk Configuration

(config)#rsvp-trunk 1	Enter the Trunk configuration mode
(config-trunk)#to 23.23.23.23	Configure the destination of the Trunk
(config-trunk)#exit	Exit.Trunk configuration mode

PE1: BGP Configuration

(config)# router bgp 100	Enter the BGP configuration mode.
(config-router)#neighbor 23.23.23.23 remote-as 100	Configure neighbor
(config-router)#neighbor 23.23.23.23 update-source 21.21.21.21	Update loopback address as source
(config-router)#address-family l2vpn vpls	Enter address family mode.
(config-router-af)#neighbor 23.23.23.23 activate	Activate the neighbor.
(config-router-af)#exit	Exit address family mode.
(config-router)#exit	Exit Router BGP mode

PE1: BGP VPLS Configuration

(config)#mpls vpls v1 25	Enter VPLS config mode
(config)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v2 26	Enter VPLS config mode

(config)#service-tpid dot1.ad	Service tp-id configuration.
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v3 27	Enter VPLS config mode
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#mpls vpls v4 28	Enter VPLS config mode
(config-vpls)#signaling bgp	Define Signaling as BGP
(config-vpls-sig)#ve-id 1	Configure VE-ID
(config-vpls-sig)#exit	Exit Signaling BGP mode
(config-vpls)#exit	Exit VPLS mode
(config)#commit	Commit candidate configuration to running configuration

P1: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 22.22.22.22/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

P1: Interface Configuration

(config)#interface xe1	Enter the Interface mode for xe1
(config-if)#ip address 10.10.23.22/24	Configure IP address on the interface.
(config-if)#enable-rsvp	Enable RSVP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter the Interface mode for xe2
(config-if)#ip address 10.10.21.22/24	Configure IP address on the interface.
(config-if)#enable-rsvp	Enable RSVP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

P1: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 22.22.22.22/32 area 0	Advertise loopback address in OSPF.

(config-router)#network 10.10.23.0/24 area 0	Advertise network address in OSPF.
(config-router)#network 10.10.21.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

P1: Global RSVP

(config)#router rsvp	Enter the Router OSPF mode.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.
(config)#commit	Commit candidate configuration to running configuration

PE2: Loopback Interface

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)#ip address 23.23.23.23/32 secondary	Configure IP address on loopback interface.
(config-if)#exit	Exit interface mode

PE2: Interface Configuration

(config)#interface xe1	Enter the Interface mode for xe1
(config-if)#ip address 10.10.21.23/24	Configure IP address on the interface.
(config-if)#enable-rsvp	Enable RSVP on the physical interface
(config-if)#label-switching	Enable label switching on the interface.
(config-if)#exit	Exit interface mode

PE2: OSPF Configuration

(config)#router ospf 100	Enter the Router OSPF mode.
(config-router)#network 23.23.23.23/32 area 0	Advertise loopback address in OSPF.
(config-router)#network 10.10.21.0/24 area 0	Advertise network address in OSPF.
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.

PE2: Global RSVP

(config)#router rsvp	Enter the Router OSPF mode.
(config-router)#exit	Exit Router RSVP mode and return to Configure mode.

PE2: RSVP-Trunk Configuration

(config)#rsvp-trunk 1	Enter the Trunk configuration mode
(config-trunk)#to 21.21.21.21	Configure the destination of the Trunk
(config-trunk)#exit	Exit.Trunk configuration mode

PE2: BGP Configuration

`(config)# router bgp 100`	Enter the BGP configuration mode.
`(config-router)#neighbor 21.21.21.21 remote-as 100`	Configure neighbor
`(config-router)#neighbor 21.21.21.21 update-source 23.23.23.23`	Update loopback address as source
`(config-router)#address-family l2vpn vpls`	Enter address family mode.
`(config-router-af)#neighbor 21.21.21.21 activate`	Activate the neighbor.
`(config-router-af)#exit`	Exit address family mode.
`(config-router)#exit`	Exit Router BGP mode

PE2: BGP VPLS Configuration

`(config)#mpls vpls v1 25`	Enter VPLS config mode
`(config)#service-tpid dot1.ad`	Service tp-id configuration.
`(config-vpls)#signaling bgp`	Define Signaling as BGP
`(config-vpls-sig)#ve-id 2`	Configure VE-ID
`(config-vpls-sig)#exit`	Exit Signaling BGP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#mpls vpls v2 26`	Enter VPLS config mode
`(config)#service-tpid dot1.ad`	Service tp-id configuration.
`(config-vpls)#signaling bgp`	Define Signaling as BGP
`(config-vpls-sig)#ve-id 2`	Configure VE-ID
`(config-vpls-sig)#exit`	Exit Signaling BGP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#mpls vpls v3 27`	Enter VPLS config mode
`(config-vpls)#signaling bgp`	Define Signaling as BGP
`(config-vpls-sig)#ve-id 2`	Configure VE-ID
`(config-vpls-sig)#exit`	Exit Signaling BGP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#mpls vpls v4 28`	Enter VPLS config mode
`(config-vpls)#signaling bgp`	Define Signaling as BGP
`(config-vpls-sig)#ve-id 2`	Configure VE-ID
`(config-vpls-sig)#exit`	Exit Signaling BGP mode
`(config-vpls)#exit`	Exit VPLS mode
`(config)#commit`	Commit candidate configuration to running configuration

BGP VPLS Service Mapping Configuration

PE1: POP

(config)#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.q	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode

PE1: XLATE

(config)#service-template template2	Template configuration
(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#exit	Exit template configuration mode

PE1: PUSH

(config)#service-template template3	Template configuration
(config-svc)# match outer-vlan 500	Match criteria under template configuration
(config-svc)# rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#exit	Exit template configuration mode

PE1: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode

PE1: Access port Configuration

(config)#interface xe1	Enter the Interface mode for xe1.
(config-if)switchport	Configure interface as L2 interface

(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-statusv	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#commit	Commit candidate configuration to running configuration

PE2: POP

(config)#configure terminal	Configure mode
(config)#service-template template1	Template configuration
(config-svc)# match double-tag outer-vlan 2024 inner-vlan 2023	Match criteria under template configuration
(config-svc)# rewrite ingress pop outgoing-tpid dot1.ad	Action to be performed for the match.
(config-svc)#exit	Exit template configuration mode

PE2: XLATE

(config)#service-template template2	Template configuration
(config-svc)# match double-tag outer-vlan 2030 inner-vlan 2024	Match criteria under template configuration
(config-svc)# rewrite ingress translate 2026 outgoing-tpid dot1.q	Action to be performed for the match
(config-svc)#exit	Exit template configuration mode

PE2: PUSH

(config)#service-template template3	Template configuration
(config-svc)# match outer-vlan 500	Match criteria under template configuration
(config-svc)# rewrite ingress push 300	Action to be performed for the default match.
(config-svc)#exit	Exit template configuration mode

PE2: PUSH-service-template with multiple match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

(config)#service-template template4	Template configuration
(config-svc)# match outer-vlan 700	Allow VLAN 700 traffic on this VC
(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200	Allow double tag match with s+c tags
(config-svc)# match untagged	Allow untagged traffic
(config-svc)# rewrite ingress push 300	Push Action performed for service template
(config-svc)#exit	Exit configure SVC mode

PE2: Access port Configuration

(config)#interface eth2	Enter the Interface mode for ethernet1.
(config-if)switchport	Configure interface as L2 interface
(config-if)#mpls-vpls v1 service-template template1	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-status	Making admin status up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v2 service-template template2	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-status	Making admin status up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v3 service-template template3	Bind the VPLS to the Access Interface.
(config-if-vpls)#no ac-admin-status	Making admin status up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#mpls-vpls v4 service-template template4	Bind the VPLS to the Access Interface.
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#no ac-admin-status	Making Ac-admin-status Up
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#exit	Exit Interface mode and return to Configure mode.
(config)#commit	Commit candidate configuration to running configuration

Validation

PE1

```
PE1#show bgp l2vpn vpls
VPLS-ID     VE-ID    Discovered-Peers   Route-Target
25          1        1                   100:25
26          1        1                   100:26
27          1        1                   100:27
28          1        1                   100:28
```

```
PE1#show bgp l2vpn vpls detail

VPLS ID: 25
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:25
Local RD: 100:25
 Mesh Peers:
  Address:23.23.23.23, RD:100:25, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25216,VBO:1,VBS:64)  Local (LB:26240,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:26241, Out Label:25216
  PW Status:Established
  VC Installed:Yes


VPLS ID: 26
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:26
Local RD: 100:26
 Mesh Peers:
  Address:23.23.23.23, RD:100:26, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25280,VBO:1,VBS:64)  Local (LB:26304,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:26305, Out Label:25280
  PW Status:Established
  VC Installed:Yes


VPLS ID: 27
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:27
Local RD: 100:27
 Mesh Peers:
  Address:23.23.23.23, RD:100:27, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25344,VBO:1,VBS:64)  Local (LB:26368,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:26369, Out Label:25344
  PW Status:Established
  VC Installed:Yes


VPLS ID: 28
VE-ID: 1
Discovered Peers: 1
Route-Target: 100:28
Local RD: 100:28
 Mesh Peers:
  Address:23.23.23.23, RD:100:28, VE-ID:2
  VC Details: VC-ID:12
  Remote (LB:25408,VBO:1,VBS:64)  Local (LB:26432,VBO:1,VBS:64)
```

```
    LB sent on known VEID:Yes
    In Label:26433, Out Label:25408
    PW Status:Established
    VC Installed:Yes

PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol  Status
25         23.23.23.23       25601         26241      xe2           25216
2/Up      1         BGP           Active
26         23.23.23.23       25601         26305      xe2           25280
2/Up      3         BGP           Active
27         23.23.23.23       25601         26369      xe2           25344
2/Up      2         BGP           Active
28         23.23.23.23       25601         26433      xe2           25408
2/Up      4         BGP           Active
```

PE2:

```
PE1#show bgp l2vpn vpls
VPLS-ID     VE-ID    Discovered-Peers   Route-Target
25          2        1                   100:25
26          2        1                   100:26
27          2        1                   100:27
28          2        1                   100:28

PE1#show bgp l2vpn vpls detail

VPLS ID: 25
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:25
Local RD: 100:25
 Mesh Peers:
  Address:21.21.21.21, RD:100:25, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26240,VBO:1,VBS:64)  Local (LB:25216,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25216, Out Label:26241
  PW Status:Established
  VC Installed:Yes
 All Local LB:
  LB:25216,VBO:1,VBS:64


VPLS ID: 26
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:26
Local RD: 100:26
```

```
 Mesh Peers:
  Address:21.21.21.21, RD:100:26, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26304,VBO:1,VBS:64)  Local (LB:25280,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25280, Out Label:26305
  PW Status:Established
  VC Installed:Yes
 All Local LB:
  LB:25280,VBO:1,VBS:64


VPLS ID: 27
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:27
Local RD: 100:27
 Mesh Peers:
  Address:21.21.21.21, RD:100:27, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26368,VBO:1,VBS:64)  Local (LB:25344,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25344, Out Label:26369
  PW Status:Established
  VC Installed:Yes
 All Local LB:
  LB:25344,VBO:1,VBS:64


VPLS ID: 28
VE-ID: 2
Discovered Peers: 1
Route-Target: 100:28
Local RD: 100:28
 Mesh Peers:
  Address:21.21.21.21, RD:100:28, VE-ID:1
  VC Details: VC-ID:21
  Remote (LB:26432,VBO:1,VBS:64)  Local (LB:25408,VBO:1,VBS:64)
  LB sent on known VEID:Yes
  In Label:25408, Out Label:26433
  PW Status:Established
  VC Installed:Yes
 All Local LB:
  LB:25408,VBO:1,VBS:64


PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport

VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol  Status
25         21.21.21.21       25600         25216      xe1            26241
2/Up      1         BGP           Active
26         21.21.21.21       25600         25280      xe1            26305
2/Up      3         BGP           Active
27         21.21.21.21       25600         25344      xe1            26369
2/Up      2         BGP           Active
```

```
28          21.21.21.21       25600          25408      xe1             26433
2/Up      4         BGP           Active

PE1#show mpls vpls detail
Virtual Private LAN Service Instance: v1, ID: 25
 SIG-Protocol: BGP
  Route-Distinguisher :100:25
  Route-Target :100:25
  VE-ID :2
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.ad
 Operating mode: Raw
 Configured interfaces:
  Interface: xe9
 Service-template : template1
  Match criteria : 2024/2023
  Action type : Pop
  Outgoing tpid : dot1.q

 Mesh Peers:
   21.21.21.21 (Up)


Virtual Private LAN Service Instance: v2, ID: 26
 SIG-Protocol: BGP
  Route-Distinguisher :100:26
  Route-Target :100:26
  VE-ID :2
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.ad
 Operating mode: Raw
 Configured interfaces:
  Interface: xe9
 Service-template : template2
  Match criteria : 2030/2024
  Action type : Translate
  Action value : 2026
  Outgoing tpid : dot1.q

 Mesh Peers:
   21.21.21.21 (Up)


Virtual Private LAN Service Instance: v3, ID: 27
 SIG-Protocol: BGP
  Route-Distinguisher :100:27
  Route-Target :100:27
```

```
  VE-ID :2
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe9
 Service-template : template3
  Match criteria : 500
  Action type : Push
  Action value : 300

 Mesh Peers:
   21.21.21.21 (Up)


Virtual Private LAN Service Instance: v4, ID: 28
 SIG-Protocol: BGP
  Route-Distinguisher :100:28
  Route-Target :100:28
  VE-ID :2
 Attachment-Circuit :UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Configured interfaces:
  Interface: xe9
 Service-template : template4
  Match criteria : 700,
 Untagged ,
 1200/3200
  Action type : Push
  Action value : 300

 Mesh Peers:
   21.21.21.21 (Up)
```

CHAPTER 9 Hierarchical VPLS

Overview

A Virtual Private LAN Service (VPLS) enables multipoint to multipoint communication, creating LAN-like connectivity between customers' sites. However, the typical full mesh topology required for LAN emulation can be impractical in large networks. To address this, Hierarchical VPLS (H-VPLS) introduces a hierarchical approach using a spoke-PW (pseudowire) type. Unlike the standard mesh-PW, the spoke-PW facilitates traffic between hierarchical levels, offering a more scalable solution for VPLS networks.

H-VPLS Redundancy Characteristics

In a Virtual Private LAN Service (VPLS) network, when a node connects through a spoke-PW, a single point of failure arises. In the event of a connection failure to the VPLS mesh or a failure within the PE-rs node, the spoke device experiences a complete loss of connectivity. To address this, PW redundancy is implemented, configuring a secondary path that activates if the primary path fails. The MTU-s is configured with a primary spoke-PW connected to PE1-rs and a secondary spoke-PW connected to PE2-rs. During normal operation, the primary spoke-PW is active, but in case of failure, the MTU-s can switch to the standby spoke-PW for continued connectivity, aiming for sub-second convergence times with potential MAC flush-related traffic loss.

Benefits

Hierarchical VPLS (H-VPLS) is introduced to address scalability challenges associated with the traditional VPLS (Virtual Private LAN Service) architecture. It introduces a hierarchical approach that enhances scalability, reduces configuration complexity, optimizes traffic flow, and improves overall network efficiency and fault tolerance.

Limitations

- Automatic revertive cases from secondary to primary will not be supported.
- MAC Address Withdrawal feature will not be supported in release 6.5.2.
- Convergence on redundancy may require bidirectional traffic or MAC aging.

Prerequisites

- The `block-mesh-spoke-on-all-ac-down` and `ignore-ac-spoke-state` commands are optional and mutually exclusive, meaning only one can be applied at a time, or neither. By default, neither command is applied. If one of commands is applied, applying the other will make it the active one. To remove a command, use the `no` prefix.

```
signaling ldp
   (block-mesh-spoke-on-all-ac-down | ignore-ac-spoke-state)
   (no block-mesh-spoke-on-all-ac-down | no ignore-ac-spoke-state)
```

- **Define Interfaces and Loopback Addresses:**
  Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connec-tivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
```

```
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128

interface xe14
 ip address 30.1.1.2/24
```

- **Configure IGP for Dynamic Routing:** Enable ISIS to facilitate dynamic routing on all nodes within the net-work. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution.Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

ISIS Configuration:

```
router isis 1
 is-type level-2-only
 metric-style wide
 microloop-avoidance level-2
 mpls traffic-eng router-id 2.2.2.2
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 bfd all-interfaces
 net 49.0000.0000.0002.00
 passive-interface lo
!
interface xe14
 mpls ldp-igp sync isis level-2
 isis network point-to-point
 ip router isis 1
```

OSPF Configuration:

```
router ospf 1
ospf router-id 2.2.2.2
network 2.2.2.2/32 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0!
!
interface xe14
ip ospf network point-to-point
```

Configuration for H-VPLS with Redundancy

Configure various nodes within the topology to set up a H-VPLS session.

Topology

This sample topology provides basic connectivity and routing between the devices.

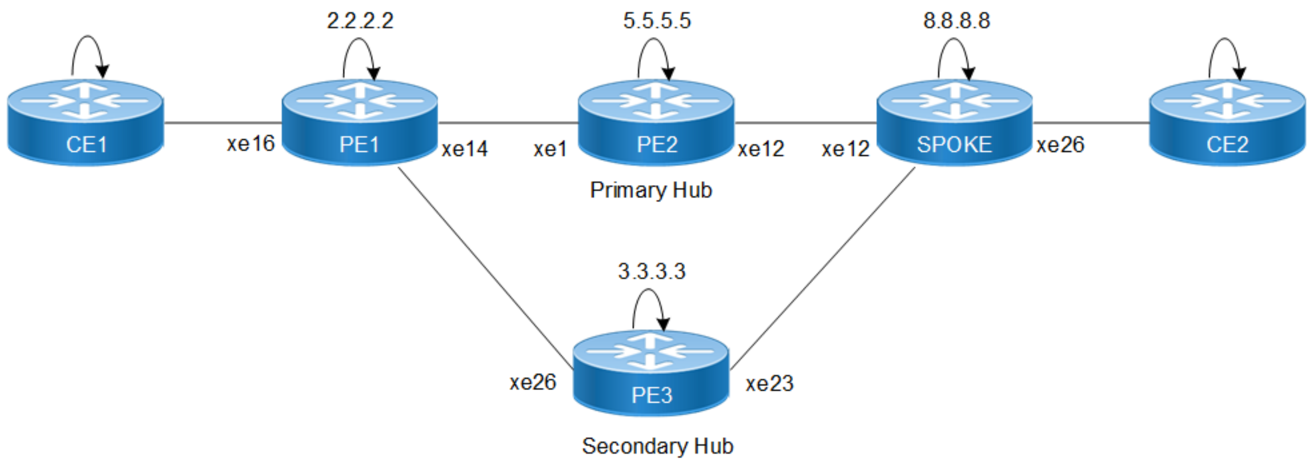

Figure 9-25: H-VPLS Configuration with Redundancy

Configure H-VPLS on PE1 Router

Follow the steps to configure the H-VPLS on PE1 router:

1. Configure router LDP.

```
PE1(config)#router ldp
PE1(config-router)# router-id 2.2.2.2
PE1(config-router)# transport-address ipv4 2.2.2.2
```

2. Configure targeted-peer under router LDP.

```
PE1(config-router)# targeted-peer ipv4 5.5.5.5
PE1(config-router-targeted-peer)#  exit-targeted-peer-mode
PE1(config-router)# targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
PE1(config)#interface xe14
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching

PE1(config)#interface xe26
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# signaling ldp
PE1(config-vpls-sig)#  vpls-peer 3.3.3.3
PE1(config-vpls-sig)#  vpls-peer 5.5.5.5
PE1(config-vpls-sig)#  exit-signaling
PE1(config-vpls)# exit-vpls
PE1(config)#
```

5. Configure sub-interface and attach vpls-instance to sub-interface.

```
PE1(config)#
PE1(config)#interface xe16.2000 switchport
PE1(config-if)# encapsulation dot1q 2000
PE1(config-if)# access-if-vpls
```

```
PE1(config-acc-if-vpls)#  mpls-vpls vpls2000
PE1(config-acc-if-vpls)#
```

Configure H-VPLS on PE2 (Primary Hub)

Follow the steps to configure the H-VPLS on PE2 (Primary Hub):

1. Configure router LDP.
```
PE2(config)#router ldp
PE2(config-router)# router-id 5.5.5.5
PE2(config-router)# transport-address ipv4 5.5.5.5
```
2. Configure targeted-peer under router LDP.
```
PE2(config)#router ldp
PE2(config-router)# targeted-peer ipv4 2.2.2.2
PE2(config-router-targeted-peer)#  exit-targeted-peer-mode
PE2(config-router)# targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#  exit-targeted-peer-mode
PE2(config-router)#
```
3. Enable LDP and label-switching for core interface.
```
PE2(config)#interface xe1
PE2(config-if)# enable-ldp ipv4
PE2(config-if)#label-switching

PE2(config)#interface xe12
PE2(config-if)# enable-ldp ipv4
PE2(config-if)#label-switching
```
4. Configure VPLS instance.
```
PE2(config)#mpls vpls vpls2000 2000
PE2(config-vpls)# signaling ldp
PE2(config-vpls-sig)#  vpls-peer 2.2.2.2
PE2(config-vpls-sig)#  vpls-peer 3.3.3.3
PE2(config-vpls-sig)#  exit-signaling
PE2(config-vpls)# exit-vpls
PE2(config)#
```
5. Configure L2-ckt.
```
PE2(config)#mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
PE2(config-pseudowire)#
```
6. Attach L2-ckt under vpls instance.
```
PE2(config)#mpls vpls vpls2000 2000
PE2(config-vpls)#vpls-vc vc2000
PE2(config-vpls-spoke)#
```

Configure H-VPLS on PE3 (Secondary Hub)

Follow the steps to configure the H-VPLS on PE3 (Secondary Hub):

1. Configure router LDP.
```
PE3(config)#router ldp
PE3(config-router)# router-id 3.3.3.3
PE3(config-router)# transport-address ipv4 3.3.3.3
```
2. Configure targeted-peer under router LDP.

```
PE3(config)#router ldp
PE3(config-router)# targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#  exit-targeted-peer-mode
PE3(config-router)# targeted-peer ipv4 5.5.5.5
PE3(config-router-targeted-peer)#  exit-targeted-peer-mode
PE3(config-router)#
```

3. Enable LDP and label-switching for core interface.

```
PE3(config)#interface xe23
PE3(config-if)# enable-ldp ipv4
PE3(config-if)#label-switching

PE3(config)#interface xe26
PE3(config-if)# enable-ldp ipv4
PE3(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE3(config)#mpls vpls vpls2000 2000
PE3(config-vpls)# signaling ldp
PE3(config-vpls-sig)#  vpls-peer 2.2.2.2
PE3(config-vpls-sig)#  vpls-peer 5.5.5.5
PE3(config-vpls-sig)#  exit-signaling
PE3(config-vpls)# exit-vpls
PE3(config)#
```

5. Configure L2-ckt.

```
PE3(config)#mpls l2-circuit vc2001 2223 8.8.8.8 mode raw
PE3(config-pseudowire)#
```

6. 6.Attach L2-ckt under vpls instance.

```
PE3 (config)#mpls vpls vpls2000 2000
PE3(config-vpls)#vpls-vc vc2001
PE3(config-vpls-spoke)#
```

Configure H-VPLS on Spoke Router

Follow the steps to configure the H-VPLS on Spoke router:

1. Configure router LDP.

```
Spoke(config)#router ldp
Spoke(config-router)# router-id 8.8.8.8
Spoke(config-router)# transport-address ipv4 8.8.8.8
```

2. Configure targeted-peer under router LDP.

```
Spoke(config-router)# targeted-peer ipv4 5.5.5.5
Spoke(config-router-targeted-peer)#  exit-targeted-peer-mode
Spoke(config-router)# targeted-peer ipv4 3.3.3.3
Spoke(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
Spoke(config)#interface xe12
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching

Spoke(config)#interface xe25
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching
```

4. Configure VPLS instance.

```
Spoke (config)#mpls vpls vpls2000 2000
Spoke (config-vpls)#
```

5. 5.Configure L2-ckt.

```
Spoke(config)#mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
Spoke(config-pseudowire)#!
Spoke(config-pseudowire)#mpls l2-circuit vc2001 2223 3.3.3.3 mode raw
Spoke(config-pseudowire)#
```

6. 6.Configure Primary and secondary spoke under vpls instance.

```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)#  secondary vc2001
Spoke(config-vpls-spoke)#  exit-spoke
Spoke(config-vpls)# exit-vpls
Spoke(config)#
```

7. Configure sub-interface and attach vpls-instance to sub-interface.

```
Spoke(config)#
Spoke(config)#interface xe26.2000 switchport
Spoke(config-if)# encapsulation dot1q 2000
Spoke(config-if)# access-if-vpls
Spoke(config-acc-if-vpls)#  mpls-vpls vpls2000
Spoke(config-acc-if-vpls)#
```

Running Configuration on PE1 Router

```
router ldp
 router-id 2.2.2.2
 targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
 targeted-peer ipv4 5.5.5.5
 transport-address ipv4 2.2.2.2
!
interface xe14
     enable-ldp ipv4
!
interface xe26
     enable-ldp ipv4
!
mpls vpls vpls2000 2000
 signaling ldp
 vpls-peer 3.3.3.3
 vpls-peer 5.5.5.5
  exit-signaling
 exit-vpls
!
interface xe16.2000 switchport
 access-if-vpls
    mpls-vpls vpls2000
```

Running Configuration on PE2 Router

```
router ldp
 targeted-peer ipv4 2.2.2.2
```

```
  exit-targeted-peer-mode
 targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
transport-address ipv4 5.5.5.5
!
mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
  exit-spoke
 signaling ldp
  vpls-peer 2.2.2.2
  vpls-peer 3.3.3.3
  exit-signaling
 exit-vpls
```

Running Configuration on PE3 Router

```
router ldp
 targeted-peer ipv4 2.2.2.2
  exit-targeted-peer-mode
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
transport-address ipv4 3.3.3.3
!
mpls l2-circuit vc2001 2223 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2001
  exit-spoke
 signaling ldp
  vpls-peer 2.2.2.2
  vpls-peer 5.5.5.5
  exit-signaling
 exit-vpls
```

Running Configuration on Spoke Router

```
router ldp
 router-id 8.8.8.8
 targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 8.8.8.8
!
mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
!
mpls l2-circuit vc2001 2223 3.3.3.3 mode raw
!
mpls vpls vpls2000 2000
vpls-vc vc2000
  secondary vc2001
  exit-spoke
 exit-vpls
!
```

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```
interface xe26.2000 switchport
 access-if-vpls
    mpls-vpls vpls2000
```

Validation

```
Validate the show output after configuration as shown below.
Verify vpls mesh are up between PE1 and Hub Nodes

PE1#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol   Status     UpTime
2000       3.3.3.3           29447         28164      xe26           27532
2/Up      3         LDP           Active     2d12h08m
2000       5.5.5.5           31364         28162      xe14           26883
2/Up      4         LDP           Active     2d12h04m

PE2#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol   Status     UpTime
2000       2.2.2.2           29446         26883      xe1         28162      2/
Up      3         LDP           Active     2d12h05m
2000       3.3.3.3           31367         26884      xe1            27528
2/Up      4         LDP           Active     2d12h15m

PE3#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr         Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol   Status     UpTime
2000       2.2.2.2           29440         27532      xe26           28164
2/Up      3         LDP           Active     2d12h10m
2000       5.5.5.5           31363         27528      xe26           26884
2/Up      4         LDP           Active     2d12h16m


Verify vpls spoke between Hub and Spoke

PE2#sho mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St   Secondary
2000       vc2000          29443         26882      xe1            26886
2/Up     ---

PE3#show mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St   Secondary
2000       vc2001          N/A           27527      N/A            26883
0/Dn     ---

Spoke#show mpls vpls spoke
```

```
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St   Secondary
2000       vc2000          29440        26886      xe12            26882
2/Up     vc2001
2000       vc2001          N/A           26883      N/A            27527
0/Dn     ---

Verify H-vpls session on Hub and spoke:

PE2#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Ignoring AC interface and spoke-VC state

 Configured interfaces:
   None

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h13m)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h22m)
 Spoke Peers:
   vc2000 (Up) (UpTime 01:31:27)


PE3#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Ignoring AC interface and spoke-VC state

 Configured interfaces:
   None

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h16m)
   5.5.5.5 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h22m)
 Spoke Peers:
   vc2001 (Dn) (Reason: VC on standby)


Spoke#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
```

```
SIG-Protocol: N/A
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw

Configured interfaces:
 Interface: xe26.2000
  Status: Up
  Subinterface Match Criteria(s) :
  dot1q 2000

Spoke Peers:
  vc2000 (Up) (UpTime 01:31:33)
   Secondary: vc2001 (Dn) (Reason: VC on standby)
```

Configuration for H-VPLS without Redundancy

Configure various nodes within the topology to set up a H-VPLS session.

Topology

This sample topology provides basic connectivity and routing between the devices.

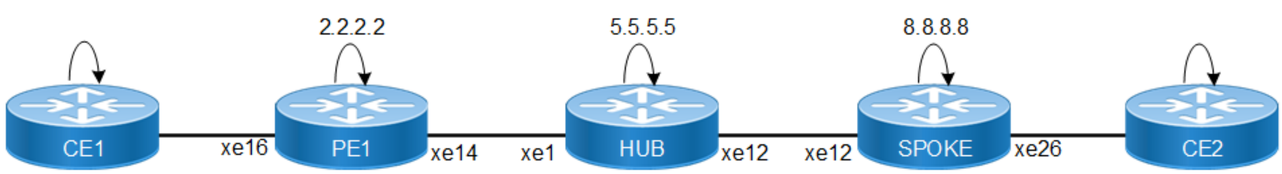


Figure 9-26: H-VPLS Configuration without Redundancy

Configure H-VPLS on PE1 Router

Follow the steps to configure the H-VPLS on PE1 router:

1. Configure router LDP.

```
PE1(config)#router ldp
PE1(config-router)# router-id 2.2.2.2
PE1(config-router)# transport-address ipv4 2.2.2.2
```

2. Configure targeted-peer under router LDP.

```
PE1(config-router)# targeted-peer ipv4 5.5.5.5
PE1(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
PE1(config)#interface xe14
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# signaling ldp
PE1(config-vpls-sig)#  vpls-peer 5.5.5.5
PE1(config-vpls-sig)#  exit-signaling
PE1(config-vpls)# exit-vpls
PE1(config)#
```

5. Configure sub-interface and attach vpls-instance to sub-interface

```
PE1(config)#
PE1(config)#interface xe16.2000 switchport
PE1(config-if)# encapsulation dot1q 2000
PE1(config-if)# access-if-vpls
PE1(config-acc-if-vpls)#  mpls-vpls vpls2000
PE1(config-acc-if-vpls)#
```

Configure H-VPLS on Hub Router

Follow the steps to configure the H-VPLS on Hub router:

1. Configure router LDP.

```
Hub(config)#router ldp
Hub(config-router)# router-id 5.5.5.5
Hub(config-router)# transport-address ipv4 5.5.5.5
```

2. Configure targeted-peer under router LDP.

```
Hub(config-router)# targeted-peer ipv4 2.2.2.2
Hub(config-router-targeted-peer)#  exit-targeted-peer-mode
R5-P5(config-router)# targeted-peer ipv4 8.8.8.8
R5-P5(config-router-targeted-peer)#
```

3. Enable LDP and label-switching for core interface.

```
Hub(config)#interface xe1
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching

Hub(config)#interface xe12
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching
```

4. Configure VPLS instance.

```
Hub(config)#mpls vpls vpls2000 2000
Hub(config-vpls)# signaling ldp
Hub(config-vpls-sig)# vpls-peer 2.2.2.2
Hub(config-vpls-sig)# exit-signaling
Hub(config-vpls)# exit-vpls
Hub(config)#
```

5. Configure L2-ckt.

```
Hub (config)#mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
Hub (config-pseudowire)#
```

6. Attach L2-ckt under vpls instance.

```
Hub (config)#mpls vpls vpls2000 2000
Hub (config-vpls)#vpls-vc vc2000
Hub(config-vpls-spoke)#
```

Configure H-VPLS on Spoke Router

Follow the steps to configure the H-VPLS on Spoke router:

1. Configure router LDP.

```
Spoke(config)#router ldp
Spoke(config-router)# router-id 8.8.8.8
Spoke(config-router)# transport-address ipv4 8.8.8.8
```

2. Configure targeted-peer under router LDP.

```
Spoke(config-router)# targeted-peer ipv4 5.5.5.5
Spoke(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
Spoke(config)#interface xe12
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching
```

4. Configure VPLS instance.

```
Spoke(config)#mpls vpls vpls2000 2000
     Spoke(config-vpls)#
```

5. Configure L2-ckt.

```
Spoke(config)#mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
Spoke(config-pseudowire)#
```

6. Attach L2-ckt under vpls instance.

```
Spoke (config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)#
```

7. Configure sub-interface and attach vpls-instance to sub-interface.

```
Spoke(config)#
Spoke(config)#interface xe26.2000 switchport
Spoke(config-if)# encapsulation dot1q 2000
Spoke(config-if)# access-if-vpls
Spoke(config-acc-if-vpls)#  mpls-vpls vpls2000
Spoke(config-acc-if-vpls)#
```

Running Configuration on PE1 Router

```
router ldp
 router-id 2.2.2.2
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 2.2.2.2
!
interface xe14
     enable-ldp ipv4
!
mpls vpls vpls2000 2000
 signaling ldp
  vpls-peer 5.5.5.5
  exit-signaling
 exit-vpls
!
interface xe16.2000 switchport
```

```
 access-if-vpls
    mpls-vpls vpls2000
```

Running Configuration on Hub Router

```
router ldp
targeted-peer ipv4 2.2.2.2
exit-targeted-peer-mode
 targeted-peer ipv4 8.8.8.8
  exit-targeted-peer-mode
!
!
mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
  exit-spoke
 signaling ldp
  vpls-peer 2.2.2.2
  exit-signaling
 exit-vpls
```

Running Configuration on Spoke Router

```
router ldp
 router-id 8.8.8.8
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 8.8.8.8
!
mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
  exit-spoke
 exit-vpls
!
interface xe26.2000 switchport
 access-if-vpls
    mpls-vpls vpls2000
```

Validation

```
Validate the show output after configuration as shown below.
Verify vpls mesh are up between PE and Hub

PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol   Status      UpTime
2000       5.5.5.5          31364         28162      xe14           26883
2/Up      4         LDP           Active     2d10h36m
```

```
Hub#sho mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol   Status     UpTime
2000       2.2.2.2          29446         26883          xe1        28162
2/Up      3         LDP           Active     2d10h39m
```

Verify vpls spoke are up between Hub and Spoke

```
Hub#sho ldp mpls-l2-circuit
Transport   Client    VC      VC           Local     Remote    Destination
Lo-cal                      Remote
VC ID       Binding    State    Type         VC Label  VC Label  Address
PW Status                   PW Status
2222        VPLS:2000  UP      Ethernet      26882     26886     8.8.8.8
Forwarding                  Forwarding

Hub#sho mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St   Secondary
2000       vc2000           29443         26882      ce4            26886
2/Up
    ---

Spoke#show ldp mpls-l2-circuit
Transport   Client    VC      VC           Local     Remote    Destination
Lo-cal                      Remote
VC ID       Binding    State    Type         VC Label  VC Label  Address
PW Status                   PW Status
2222        VPLS:2000  UP      Ethernet      26886     26882     5.5.5.5
Forwarding                  Forwarding

Spoke#show mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St   Secondary
2000       vc2000           29440         26886      ce4            26882
2/Up     ---
```

Verify H-vpls session on Hub and spoke:

```
Hub#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 Ignoring AC interface and spoke-VC state

 Configured interfaces:
   None
```

```
 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d10h47m)
   3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d10h56m)
 Spoke Peers:
   vc2000 (Up) (UpTime 00:05:48)


Spoke#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: N/A
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw

 Configured interfaces:
  Interface: xe26.2000
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2000

 Spoke Peers:
   vc2000 (Up) (UpTime 00:07:47)
```

Commands for H-VPLS Configuration

The H-VPLS uses the following configuration commands.

vpls-vc

Use this command to add a spoke virtual circuit to VPLS domain hierarchically.

Use `no` parameter of this command to remove this configuration.

Command Syntax

```
vpls-vc NAME
 (secondary NAME|)
 (ethernet|vlan|)
```

Parameters

`NAME`	Specifies the name of the VPLS. It is a string that identifies the MPLS VC to add to the VPLS domain.
`secondary`	Specifies the name of the secondary spoke.
`NAME`	Specifies the name for the secondary spoke.
`ethernet`	Specifies the spoke type. Defaults to `ethernet`.
`vlan`	Specifies the spoke type.

Default

Disabled

Command Mode

VPLS mode

Applicability

Introduced before OcNOS version 1.3.

Modified the command prompt into a hierarchical structure from single line in the OcNOS version 6.5.1.

Example

Example for adding a spoke virtual circuit with VPLS name vc1 and secondary spoke vc2:

```
#configure terminal
(config)#mpls vpls vpls1 3000
(config-vpls)#vpls-vc vc1
(config-vpls-spoke)#secondary vc2
(config-vpls-spoke)#type ethernet
(config-vpls-spoke)#exit-spoke
(config-vpls)#exit
```

Example to remove the configuration of the spoke virtual circuit with VPLS name vc1:

```
#configure terminal
(config)#mpls vpls vpls1 3000
(config-vpls)#no vpls-vc vc1
(config-vpls)#exit
```

signaling

Use this command to set all mesh and spoke pseudowires to down when all access interfaces are down.

Use `ignore-ac-spoke-state` parameter of this command to remove this configuration.

Command Syntax

```
signaling ldp block-mesh-spoke-on-all-ac-down
```

```
signaling ignore-ac-spoke-state
```

Parameters

`block-mesh-spoke-on-all-ac-down`	(Optional) Controls the behavior of pseudowires (PWs) in a VPLS instance when all access interfaces associated with the VPLS instance are down.
`ignore-ac-spoke-state`	Ignores access interfaces and spoke pseudowires state and keep mesh pseudowires up.

Default

disabled

Command Mode

VPLS mode

Applicability

Introduced before OcNOS version 1.3.

Modified the command prompt into a hierarchical structure from single line in the OcNOS version 6.5.1.

Example

Example for setting up all mesh and spoke pseudowires to down when all access interfaces are down:

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#block-mesh-spoke-on-all-ac-down
(config-vpls-sig)#exit
```

Example for setting up all mesh and spoke pseudowires to up:

```
#configure terminal
(config)# mpls vpls test 100
(config-vpls)#signaling ldp
(config-vpls-sig)#ignore-ac-spoke-state
(config-vpls-sig)#exit
```

CHAPTER 10 MAC Withdrawal - VPLS/H-VPLS

Overview

The MAC withdrawal mechanism allows for faster convergence by immediately clearing dynamically learned MAC addresses upon detecting a switchover event, rather than waiting for the usual aging process. This process is triggered by specific network events or state changes, such as:

- Spoke-PW switchover: A path between two VPLS network elements, typically between MTU-s (Multi-Tenant Units) and Provider Edge (PE) routers, transitions from standby to active or vice versa.
- MLAG switchover: When a link failure or node failure occurs in a MLAG setup, leading to the activation of a previously standby link.

The main goal is to ensure that MAC addresses learned from any given path (spoke or mesh) are promptly removed when a switchover occurs, preventing stale entries from affecting the network.

The MAC withdrawal message, defined as the LDP Positive MAC Flush message, is used to remove MAC address tables. This message can be triggered either by MTU-s or PE-rs depending on the network topology and the specific trigger event (such as a switchover or link failure).

Characteristics of MAC Withdrawal - VPLS/H-VPLS

- MAC Withdrawal is used to speed up network convergence during topology changes.
- It ensures that dynamically learned MAC addresses are flushed proactively instead of aging out, reducing traffic disruption.
- Triggers for MAC Withdrawal:
  - **Spoke PW Switchover:** When a Spoke Pseudowire (PW) transitions between active and standby.
  - **MLAG Switchover:** When a multi-chassis link aggregation (MLAG) event causes a switchover between active and standby devices.
  - **Node Failure:** When a PE-rs (Provider Edge router) or MTU-s (Multi-Tenant Unit switch) fails or reboots.
  - **PW Status TLV:** The Preferential Forwarding Status bit in an LDP PW Status TLV can signal a switchover.
  - **Manual Intervention:** Administrators can trigger MAC withdrawal manually for network maintenance.

Benefits

- Proactively removes outdated MAC entries, reducing the time taken for the network to stabilize.
- Ensures quick adaptation to topology changes without requiring manual intervention.
- Reduces packet flooding by clearing invalid MAC table entries.
- Prevents stale forwarding information, ensuring accurate traffic routing.
- Ensures seamless transition when a standby link becomes active.
- Enables compatibility with industry-standard VPLS/H-VPLS deployments.
- Prevents unnecessary flushing across Mesh PWs, maintaining stability.

Prerequisites

- Define Interfaces and Loopback Addresses:

  Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connec-tivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128

interface xe14
 ip address 30.1.1.2/24
```

- **Configure IGP for Dynamic Routing:**

  Enable ISIS to facilitate dynamic routing on all nodes within the net-work. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution.Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

  - ISIS Configuration:

```
router isis 1
 is-type level-2-only
 metric-style wide
 microloop-avoidance level-2
 mpls traffic-eng router-id 2.2.2.2
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 bfd all-interfaces
 net 49.0000.0000.0002.00
 passive-interface lo
!
interface xe14
 mpls ldp-igp sync isis level-2
 isis network point-to-point
 ip router isis 1
```

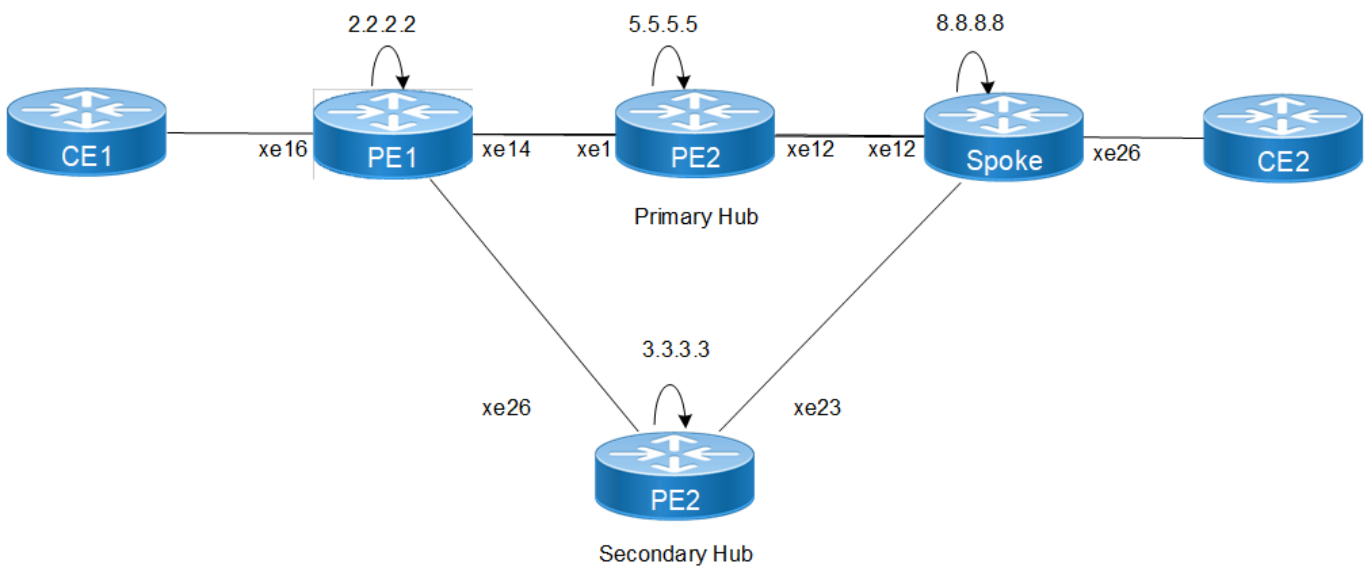
  - OSPF Configuration:

```
router ospf 1
ospf router-id 2.2.2.2
network 2.2.2.2/32 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0!
!
interface xe14
ip ospf network point-to-point
```

Configuration

Topology

This topology represents MAC withdrawal for VPLS/H-VPLS with Primary and Secondary Hub architecture.



MAC Withdrawal for VPLS/H-VPLS Topology

Configuring H-VPLS

Configure PE1 router as follows:

1. Configure router LDP.

```
PE1(config)#router ldp
PE1(config-router)# router-id 2.2.2.2
PE1(config-router)# transport-address ipv4 2.2.2.2
```

2. Configure targeted-peer under router LDP.

```
PE1(config-router)# targeted-peer ipv4 5.5.5.5
PE1(config-router-targeted-peer)#  exit-targeted-peer-mode
PE1(config-router)# targeted-peer ipv4 3.3.3.3
PE1(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
PE1(config)#interface xe14
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching

PE1(config)#interface xe26
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# signaling ldp
PE1(config-vpls-sig)#  vpls-peer 3.3.3.3
PE1(config-vpls-sig)#  vpls-peer 5.5.5.5
PE1(config-vpls-sig)#  exit-signaling
PE1(config-vpls)# exit-vpls
PE1(config)#
```

5. Configure sub-interface and attach vpls-instance to sub-interface.

```
PE1(config)#
PE1(config)#interface xe16.2000 switchport
PE1(config-if)# encapsulation dot1q 2000
PE1(config-if)# access-if-vpls
PE1(config-acc-if-vpls)#  mpls-vpls vpls2000
PE1(config-acc-if-vpls)#
```

Configuring the H-VPLS MAC-Withdrawal on PE2 (Primary Hub):

1. Configure router LDP.

```
PE2(config)#router ldp
PE2(config-router)# router-id 5.5.5.5
PE2(config-router)# transport-address ipv4 5.5.5.5
```

2. Configure targeted-peer under router LDP.

```
PE2(config)#router ldp
PE2(config-router)# targeted-peer ipv4 2.2.2.2
PE2(config-router-targeted-peer)#  exit-targeted-peer-mode
PE2(config-router)# targeted-peer ipv4 3.3.3.3
PE2(config-router-targeted-peer)#  exit-targeted-peer-mode
PE2(config-router)#
```

3. Enable LDP and label-switching for core interface

```
PE2(config)#interface xe1
PE2(config-if)# enable-ldp ipv4
PE2(config-if)#label-switching

PE2(config)#interface xe12
PE2(config-if)# enable-ldp ipv4
PE2(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE2(config)#mpls vpls vpls2000 2000
PE2(config-vpls)# signaling ldp
PE2(config-vpls-sig)#  vpls-peer 2.2.2.2
PE2(config-vpls-sig)#  vpls-peer 3.3.3.3
PE2(config-vpls-sig)#  exit-signaling
PE2(config-vpls)# exit-vpls
PE2(config)#
```

5. Configure L2-ckt.

```
PE2 (config)#mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
PE2(config-pseudowire)#
```

6. Attach L2-ckt under vpls instance.

```
PE2 (config)#mpls vpls vpls2000 2000
PE2(config-vpls)#vpls-vc vc2000
PE2(config-vpls-spoke)#
```

7. Configure mac-withdrawal under VPLS instance.

```
PE2(config-vpls-spoke)#mpls vpls vpls2000 2000
PE2(config-vpls)# vpls-vc vc2000
PE2(config-vpls-spoke)#  exit-spoke
PE2(config-vpls)# mac-withdrawal flush-propagate-spoke-to-mesh
PE2(config-vpls)#exit
PE2(config)#
```

Configuring the H-VPLS on PE3 (Secondary Hub):

1. Configure router LDP.

```
PE3(config)#router ldp
PE3(config-router)# router-id 3.3.3.3
PE3(config-router)# transport-address ipv4 3.3.3.3
```

2. Configure targeted-peer under router LDP.

```
PE3(config)#router ldp
PE3(config-router)# targeted-peer ipv4 2.2.2.2
PE3(config-router-targeted-peer)#  exit-targeted-peer-mode
PE3(config-router)# targeted-peer ipv4 5.5.5.5
PE3(config-router-targeted-peer)#  exit-targeted-peer-mode
PE3(config-router)#
```

3. Enable LDP and label-switching for core interface.

```
PE3(config)#interface xe23
PE3(config-if)# enable-ldp ipv4
PE3(config-if)#label-switching

PE3(config)#interface xe26
PE3(config-if)# enable-ldp ipv4
PE3(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE3(config)#mpls vpls vpls2000 2000
PE3(config-vpls)# signaling ldp
PE3(config-vpls-sig)#  vpls-peer 2.2.2.2
PE3(config-vpls-sig)#  vpls-peer 5.5.5.5
PE3(config-vpls-sig)#  exit-signaling
PE3(config-vpls)# exit-vpls
PE3(config)#
```

5. 5.Configure L2-ckt.

```
PE3(config)#mpls l2-circuit vc2001 2223 8.8.8.8 mode raw
PE3(config-pseudowire)#
```

6. Attach L2-ckt under VPLS instance.

```
PE3 (config)#mpls vpls vpls2000 2000
PE3(config-vpls)#vpls-vc vc2001
PE3(config-vpls-spoke)#
```

7. Configure mac-withdrawal under VPLS instance.

```
PE3(config)#mpls vpls vpls2000 2000
PE3(config-vpls)# vpls-vc vc2001
PE3(config-vpls-spoke)#  exit-spoke
PE3(config-vpls)# mac-withdrawal flush-propagate-spoke-to-mesh
PE3(config-vpls)#exit
PE3(config)#
```

Configuring the H-VPLS on Spoke Router:

1. Configure router LDP.

```
Spoke(config)#router ldp
Spoke(config-router)# router-id 8.8.8.8
Spoke(config-router)# transport-address ipv4 8.8.8.8
```

2. Configure targeted-peer under router LDP.

```
Spoke(config-router)# targeted-peer ipv4 5.5.5.5
Spoke(config-router-targeted-peer)#  exit-targeted-peer-mode
Spoke(config-router)# targeted-peer ipv4 3.3.3.3
Spoke(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
Spoke(config)#interface xe12
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching

Spoke(config)#interface xe25
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching
```

4. Configure VPLS instance.

```
Spoke (config)#mpls vpls vpls2000 2000
Spoke (config-vpls)#
```

5. Configure L2-ckt.

```
Spoke(config)#mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
Spoke(config-pseudowire)#!
Spoke(config-pseudowire)#mpls l2-circuit vc2001 2223 3.3.3.3 mode raw
Spoke(config-pseudowire)#
```

6. Configure Primary and Secondary spoke under VPLS instance.

```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)#  secondary vc2001
Spoke(config-vpls-spoke)#  exit-spoke
Spoke(config-vpls)# exit-vpls
Spoke(config)#
```

7. Configure sub-interface and attach vpls-instance to sub-interface.

```
Spoke(config)#
Spoke(config)#interface xe26.2000 switchport
Spoke(config-if)# encapsulation dot1q 2000
Spoke(config-if)# access-if-vpls
Spoke(config-acc-if-vpls)#  mpls-vpls vpls2000
Spoke(config-acc-if-vpls)#
```

8. Configure mac-withdrawal under VPLS instance.

```
Spoke(config)#mpls  vpls vpls2000 2000
Spoke(config-vpls)#mac-withdrawal flush-on-spoke-vc-standby-activation
Spoke(config-vpls)#commit
Spoke(config-vpls)#
```

Running Configuration on PE1 Router:

```
router ldp
 router-id 2.2.2.2
 targeted-peer ipv4 3.3.3.3
```

```
  exit-targeted-peer-mode
 targeted-peer ipv4 5.5.5.5
 transport-address ipv4 2.2.2.2
!
interface xe14
     enable-ldp ipv4
!
interface xe26
     enable-ldp ipv4
!
mpls vpls vpls2000 2000
 signaling ldp
 vpls-peer 3.3.3.3
 vpls-peer 5.5.5.5
  exit-signaling
 exit-vpls
!
interface xe16.2000 switchport
 access-if-vpls
    mpls-vpls vpls2000
```

Running Configuration on PE2 Router:

```
router ldp
 targeted-peer ipv4 2.2.2.2
  exit-targeted-peer-mode
 targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
transport-address ipv4 5.5.5.5
!
mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
  exit-spoke
mac-withdrawal flush-propagate-spoke-to-mesh
 signaling ldp
  vpls-peer 2.2.2.2
  vpls-peer 3.3.3.3
  exit-signaling
 exit-vpls
```

Running Configuration on PE3 Router:

```
router ldp
 targeted-peer ipv4 2.2.2.2
  exit-targeted-peer-mode
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
transport-address ipv4 3.3.3.3
!
mpls l2-circuit vc2001 2223 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2001
  exit-spoke
exit-spoke
```

```
 mac-withdrawal flush-propagate-spoke-to-mesh
 signaling ldp
  vpls-peer 2.2.2.2
  vpls-peer 5.5.5.5
  exit-signaling
 exit-vpls
```

Running Configuration on Spoke Router:

```
router ldp
 router-id 8.8.8.8
 targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 8.8.8.8
!
mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
!
mpls l2-circuit vc2001 2223 3.3.3.3 mode raw
!
mpls vpls vpls2000 2000
vpls-vc vc2000
  secondary vc2001
  exit-spoke
mac-withdrawal flush-on-spoke-vc-standby-activation
 exit-vpls
!
interface xe26.2000 switchport
 access-if-vpls
    mpls-vpls vpls2000
```

Validation

PE2#show mpls vpls vpls2000

```
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 MAC Withdrawal:
   Propagated to the mesh peers from the hub

 Configured interfaces:
   None

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h13m)
```

```
    3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h22m)
  Spoke Peers:
    vc2000 (Up) (UpTime 01:31:27)
```

PE3#show mpls vpls vpls2000

```
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 MAC Withdrawal:
   Propagated to the mesh peers from the hub

 Configured interfaces:
   None

 Mesh Peers:
   2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h16m)
   5.5.5.5 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d12h22m)
 Spoke Peers:
   vc2001 (Dn) (Reason: VC on standby)
```

Spoke#show mpls vpls vpls2000

```
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: N/A
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 1500
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
  MAC Withdrawal:
   Sent on switchover from secondary spoke to primary spoke

 Configured interfaces:
  Interface: xe26.2000
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2000

 Spoke Peers:
   vc2000 (Up) (UpTime 01:31:33)
    Secondary: vc2001 (Dn) (Reason: VC on standby)
```

CLI Commands

The MAC Withdrawal for VPLS/H-VPLS introduces the following configuration commands.

mac-withdrawal flush-on-spoke-vc-standby-activation

Use this command to send MAC withdraw when the secondary spoke becomes the primary.

Use `no` parameter of this command to remove MAC withdraw when the secondary spoke becomes the primary.

Command Syntax

```
mac-withdrawal flush-on-spoke-vc-standby-activation
no mac-withdrawal flush-on-spoke-vc-standby-activation
```

Parameters

None

Default

None

Command Mode

VPLS Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

Explain or describe the example.

```
#configure terminal
(config)#mpls vpls vpls12 12
(config-vpls)#mac-withdrawal flush-on-spoke-vc-standby-activation
```

mac-withdrawal flush-propagate-spoke-to-mesh

Use this command to allow propagation of MAC withdraw from spoke to mesh.

Use `no` parameter of this command to remove propagation of MAC withdraw from spoke to mesh.

Command Syntax

```
mac-withdrawal flush-propagate-spoke-to-mesh
```

Parameters

None

Default

None

Command Mode

VPLS Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

Explain or describe the example.

```
#configure terminal
(config)#mpls vpls vpls12 12
(config-vpls)#mac-withdrawal flush-propagate-spoke-to-mesh
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
H-VPLS	Hierarchical Virtual Private LAN Service
VPLS	Virtual Private LAN Service

CHAPTER 11 MAC Move Protection - VPLS/H-VPLS

Overview

MAC Move Protection is a Layer 2 feature for detecting and managing the movement of MAC addresses across various interfaces in Virtual Private LAN Service (VPLS) or Hierarchical VPLS (H-VPLS) networks.

In VPLS environments, MAC address moves can occur across Attachment Circuits (AC), Spoke-PWs, and Mesh-PWs. MAC Move Protection is particularly useful in detecting and responding to these movements within these different components.

Characteristics of MAC Move Protection - VPLS/H-VPLS

- Monitors MAC address movements across Attachment Circuits (AC), Spoke-PWs, and Mesh-PWs, detecting any moves between these components in a VPLS/H-VPLS topology.
- Enables detection settings across multiple VPLS instances, ensuring uniformity and reducing redundant configurations.
- Allows more granular control, enabling overrides for detection timers and error-disable actions on specific instances.
- Administrators can configure detection interval and move count threshold.
- When a MAC move is detected, this feature:
    - Applies error-disable actions to ACs to prevent disruption.
    - Brings down Spoke-PWs or Mesh-PWs, reducing impact on the network.
    - Automatically restores components after the error-disable or operational down actions are triggered.

Benefits

- By detecting and managing unexpected MAC address moves, the feature helps prevent network loops, service disruptions, and performance degradation, ensuring stable VPLS connectivity.
- The action mechanism minimizes disruptions by intelligently deciding which components to block (AC, Spoke-PW, or Mesh-PW) based on priority, reducing the impact of MAC move events on the overall network.
- With syslog reporting and detailed CLI commands, network administrators can quickly identify and address MAC move issues.
- The ability to configure detection settings both globally and at the instance level provides flexibility in managing large-scale VPLS networks.

Prerequisites

- **Define Interfaces and Loopback Addresses:**

  Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connec-tivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
```

```
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128

interface xe14
 ip address 30.1.1.2/24
```

- **Configure IGP for Dynamic Routing:**
  Enable ISIS to facilitate dynamic routing on all nodes within the net-work. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution.Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.
  - **ISIS Configuration:**

```
router isis 1
 is-type level-2-only
 metric-style wide
 microloop-avoidance level-2
 mpls traffic-eng router-id 2.2.2.2
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
      bfd all-interfaces
 net 49.0000.0000.0002.00
 passive-interface lo
!
interface xe14
 mpls ldp-igp sync isis level-2
 isis network point-to-point
 ip router isis 1
```

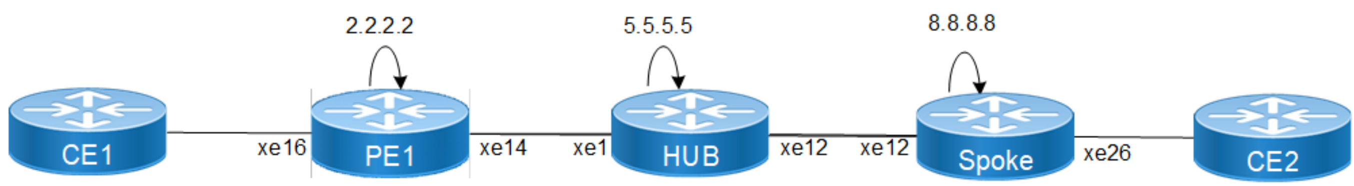
  - **OSPF Configuration:**

```
router ospf 1
ospf router-id 2.2.2.2
network 2.2.2.2/32 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0!
!
interface xe14
ip ospf network point-to-point
```

Configuration

Topology

The sample topology for MAC Move Protection with CE-PE-Hub-Spoke architecture.



MAC Move Protection Topology Diagram

Configuring MAC Move Protection

Configure PE1 router as follows:

1. Configure router LDP.

```
PE1(config)#router ldp
PE1(config-router)# router-id 2.2.2.2
PE1(config-router)# transport-address ipv4 2.2.2.2
```

2. Configure targeted-peer under router LDP.

```
PE1(config-router)# targeted-peer ipv4 5.5.5.5
PE1(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
PE1(config)#interface xe14
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# signaling ldp
PE1(config-vpls-sig)#  vpls-peer 5.5.5.5
PE1(config-vpls-sig)#  exit-signaling
PE1(config-vpls)# exit-vpls
PE1(config)#
```

5. Configure sub-interface and attach vpls-instance to sub-interface.

```
PE1(config)#
PE1(config)#interface xe16.2000 switchport
PE1(config-if)# encapsulation dot1q 2000
PE1(config-if)# access-if-vpls
PE1(config-acc-if-vpls)#  mpls-vpls vpls2000
PE1(config-acc-if-vpls)#
```

6. MAC-MOVE global configuration.

```
PE1(config)#vpls mac-move enable detect 10 10
PE1(config)#commit
PE1(config)#
```

7. Configure MAC-MOVE under VPLS instance.

```
PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# mac-move
PE1(config-vpls-mac-move)#  detect 10 10
PE1(config-vpls-mac-move)#  errdisable timeout-interval 120
PE1(config-vpls-mac-move)#commit
PE1(config-vpls-mac-move)#
PE1(config-vpls-mac-move)#exit
PE1(config)#
```

Configure the Hub Router:

1. Configure router LDP.

```
Hub(config)#router ldp
Hub(config-router)# router-id 5.5.5.5
Hub(config-router)# transport-address ipv4 5.5.5.5
```

2. Configure targeted-peer under router LDP.

```
Hub(config-router)# targeted-peer ipv4 2.2.2.2
Hub(config-router-targeted-peer)#  exit-targeted-peer-mode
R5-P5(config-router)# targeted-peer ipv4 8.8.8.8
R5-P5(config-router-targeted-peer)#
```

3. Enable LDP and label-switching for core interface.

```
Hub(config)#interface xe1
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching
Hub(config)#interface xe12
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching
```

4. Configure VPLS instance.

```
Hub(config)#mpls vpls vpls2000 2000
Hub(config-vpls)# signaling ldp
Hub(config-vpls-sig)#  vpls-peer 2.2.2.2
Hub(config-vpls-sig)#  exit-signaling
Hub(config-vpls)# exit-vpls
Hub(config)#
```

5. Configure L2-ckt.

```
Hub (config)#mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
Hub (config-pseudowire)#
```

6. Attach L2-ckt under VPLS instance.

```
Hub (config)#mpls vpls vpls2000 2000
Hub (config-vpls)#vpls-vc vc2000
Hub(config-vpls-spoke)#
```

7. MAC Move Protection global configuration.

```
Hub(config)#vpls mac-move enable detect 10 10
Hub(config)#commit
Hub(config)#
```

8. Configure MAC-MOVE under VPLS instance.

```
Hub(config)#mpls vpls vpls2000 2000
Hub(config-vpls)# mac-move
Hub(config-vpls-mac-move)#  detect 10 10
Hub(config-vpls-mac-move)#  errdisable timeout-interval 120
```

```
Hub(config-vpls-mac-move)#  errdisable allow-mesh-pw-blocking
Hub(config-vpls-mac-move)#exit
Hub(config)#PE1(config)#
```

Configure Spoke Router as follows:

1. Configure router LDP.
```
Spoke(config)#router ldp
Spoke(config-router)# router-id 8.8.8.8
Spoke(config-router)# transport-address ipv4 8.8.8.8
```
2. Configure targeted-peer under router LDP.
```
Spoke(config-router)# targeted-peer ipv4 5.5.5.5
Spoke(config-router-targeted-peer)#  exit-targeted-peer-mode
```
3. Enable LDP and label-switching for core interface.
```
Spoke(config)#interface xe12
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching
```
4. Configure VPLS instance.
```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#
```
5. Configure L2-ckt.
```
Spoke(config)#mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
Spoke(config-pseudowire)#
```
6. Attach L2-ckt under VPLS instance.
```
Spoke (config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)#
```
7. MAC Move Protection global configuration
```
Spoke(config)#vpls mac-move enable detect 10 10
Spoke(config)#commit
Spoke(config)#
```
8. Configure MAC-MOVE under VPLS instance.
```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)# mac-move
Spoke(config-vpls-mac-move)#  detect 10 10
Spoke(config-vpls-mac-move)#  errdisable timeout-interval 120
Spoke(config-vpls-mac-move)#  errdisable allow-mesh-pw-blocking
Spoke(config-vpls-mac-move)#exit
Spoke(config)#PE1(config)#
```

Running Configuration on PE1 Router:

```
router ldp
 router-id 2.2.2.2
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 2.2.2.2
!
interface xe14
     enable-ldp ipv4
!
mpls vpls vpls2000 2000
```

```
 signaling ldp
  vpls-peer 5.5.5.5
exit-signaling
 mac-move
  detect 10 10
  errdisable timeout-interval 120
   exit-mac-move
 exit-vpls
!
interface xe16.2000 switchport
 access-if-vpls
  mpls-vpls vpls2000
  learning limit prof1
```

Running Configuration on Hub Router:

```
router ldp
targeted-peer ipv4 2.2.2.2
exit-targeted-peer-mode
 targeted-peer ipv4 8.8.8.8
  exit-targeted-peer-mode
!
!
mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
learning limit prof1
  exit-spoke
 signaling ldp
  vpls-peer 2.2.2.2
  exit-signaling
mac-move
  detect 10 10
  errdisable timeout-interval 120
  errdisable allow-mesh-pw-blocking
   exit-mac-move
 exit-vpls
 exit-vpls
```

Running Configuration on Spoke Router:

```
router ldp
 router-id 8.8.8.8
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 8.8.8.8
!
mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
  exit-spoke
  exit-signaling
 mac-move
  detect 10 10
  errdisable timeout-interval 120
  errdisable allow-mesh-pw-blocking
```

```
    exit-mac-move
  exit-vpls!
interface xe26.2000 switchport
  access-if-vpls
     mpls-vpls vpls2000
```

Validation

When mac move is seen on Hub:

```
-----------------------------------------------
HUB#2025 Jan 22 11:12:34.684 : HUB : NSM : NOTIF : [IFMGR_ERR_DISABLE_UP_4]:
Mesh with Peer 2.2.2.2 on VPLS instance vpls2000 recovered from operational
shutdown
2025 Jan 22 11:12:34.687 : HUB : NSM : NOTIF :
[NSM_MPLS_VPLS_PEER_STATE_CHANGE_4]: VPLS vpls2000 ID 2000 peer 2.2.2.2
changed state to up
2025 Jan 22 11:12:34.695 : HUB : NSM : CRITI : [IFMGR_ERR_DISABLE_DOWN_2]:
Mesh with peer 3.3.3.3 on VPLS instance vpls2000 shutdown successfully
2025 Jan 22 11:12:34.697 : HUB : NSM : CRITI :
[NSM_MPLS_VPLS_PEER_STATE_CHANGE_2]: VPLS vpls2000 ID 2000 peer 3.3.3.3
changed state to down (Reason: VPLS peer errdisable)
2025 Jan 22 11:12:37.196 : HUB : HSL : CRITI : L2 movement detected 221 times
: sample MAC : 0000:0000:0009 from PEER : 2.2.2.2
```

Hub#show mpls vpls vpls2000

```
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Enabled
 Flow Label Status: Enabled, Direction: Both, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 5000
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 MAC Withdrawal:

 Configured interfaces:
  Interface: xe2.2000
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2000

 Mesh Peers:
   2.2.2.2 (Type: Ethernet VLAN) (Negotiated - CW: Yes, FAT: No) (Up) (UpTime:
2d00h01m)
    FEC signaling element: FEC128
   3.3.3.3 (Type: Ethernet VLAN) (Negotiated - CW: Yes, FAT: No) (Up) (UpTime:
01:44:45)
    FEC signaling element: FEC128
 Spoke Peers:
   vc2000 (Dn) (Reason: VPLS peer errdisable)
```

When mac move is cleared on Hub:

```
-------------------------------------------------
HUB#2025 Jan 22 11:17:34.697 : HUB : NSM : NOTIF : [IFMGR_ERR_DISABLE_UP_4]:
Mesh with Peer 3.3.3.3 on VPLS instance vpls2000 recovered from operational
shutdown
2025 Jan 22 11:17:34.700 : HUB : NSM : NOTIF :
[NSM_MPLS_VPLS_PEER_STATE_CHANGE_4]: VPLS vpls2000 ID 2000 peer 3.3.3.3
changed state to up
```

Hub#show mpls vpls vpls2000

```
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Enabled
 Flow Label Status: Enabled, Direction: Both, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 5000
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 MAC Withdrawal:

 Configured interfaces:
  Interface: xe2.2000
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2000

 Mesh Peers:
   2.2.2.2 (Type: Ethernet VLAN) (Negotiated - CW: Yes, FAT: No) (Up) (UpTime:
2d00h01m)
    FEC signaling element: FEC128
   3.3.3.3 (Type: Ethernet VLAN) (Negotiated - CW: Yes, FAT: No) (Up) (UpTime:
01:44:45)
    FEC signaling element: FEC128

 Spoke Peers:
   vc2000 (Dn) (Reason: VC on standby)
```

When mac move is seen on PE1:

```
----------------------------------------------------------
```

PE1#show mpls vpls vpls2001

```
Virtual Private LAN Service Instance: vpls2001, ID: 2001
 SIG-Protocol: LDP
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Enabled
 Flow Label Status: Enabled, Direction: Both, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 5000
 Description: none
 service-tpid: dot1.q
```

```
Operating mode: Tagged
Svlan Id: 0
Svlan Tpid: 8100
MAC Withdrawal:

Configured interfaces:
 Interface: xe16.2001
  Status: Down
  Subinterface Match Criteria(s) :
  dot1q 2001

Mesh Peers:
  3.3.3.3 (Type: Ethernet VLAN) (Negotiated - CW: Yes, FAT: Yes) (Up)
(UpTime: 01:53:26)
   FEC signaling element: FEC128
  5.5.5.5 (Type: Ethernet VLAN) (Negotiated - CW: Yes, FAT: Yes) (Up)
(UpTime: 2d00h09m)
   FEC signaling element: FEC128
```

PE1#show interface brief | grep xe16.2001

```
xe16.2001          SUBINTERFACE  --    --               down    ED      10g
--       No  No
PE1#
```

CLI Commands

The MAC Move Protection introduces the following configuration commands.

vpls mac-move enable detect

Use this command to enable MAC address move detection within a VPLS environment with global configuration.

Use `no` parameter of this command to disable MAC address move detection

Command Syntax

```
vpls mac-move enable detect <1-1000> <5-300>
no vpls mac-move enable detect
```

Parameters

`<1-1000>`	Specifies the number of detected MAC address moves required to trigger an action. The default value is 5.
`<5-300>`	Specifies the time period (in seconds) within which the specified number of MAC address moves must occur for the move to be considered valid. The default value is 15 seconds.

Default

Disabled

Command Mode

CONFIG mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

The following example is for configuration of MAC move protection using global configuration:

```
#configure terminal
(config)#vpls mac-move enable detect 10 40
(config)#commit
```

mac-move

Use this command to enable MAC address move detection within a VPLS environment with VPLS MAC MOVE mode.

Use `no` parameter of this command to disable MAC address move detection

Command Syntax

```
mac-move detect (<1-1000> | <5-300>) | errdisable (allow-mesh-pw-blocking |
  timeout-interval <0-86400>)
```

```
no mac-move
```

Parameters

`<1-1000>`	Specifies the number of detected MAC address moves required to trigger an action. The default value is 5.
`<5-300>`	Specifies the time period (in seconds) within which the specified number of MAC address moves must occur for the move to be considered valid. The default value is 15 seconds.
`allow-mesh-pw-blocking`	Allows blocking the Mesh Pseudowire (PW) instead of only disabling the MAC in case of an error.
`<0-86400>`	(Optional) Specifies the MAC move errdisable timeout interval, determining how long the affected MAC remains disabled before being re-enabled. The default value is 0 second.

Default

Disabled

Command Mode

VPLS MAC MOVE mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

The following example is for configuration of MAC move protection for VPLS instance:

```
#configure terminal
(config)# mpls vpls vpls_test1 100
(config-vpls)#mac-move
(config-vpls-mac-move)# detect 10  60
(config-vpls-mac-move)# errdisable timeout interval 120
(config-vpls-mac-move)# errdisable allow-mesh-pw-blocking
(config-vpls-mac-move)# exit-mac-move
(config-vpls)# exit-vpls
```

show mpls vpls mac-move name

Use this command to display the MAC address move configuration and status for the VPLS instance.

Command Syntax

```
show mpls vpls mac-move name
```

Parameters

`name`	Specifies the name of VPLS instance.

Applicability

Introduced in OcNOS version 6.6.0.

Example

The following example is for configuration of MAC move protection:

```
#show mpls vpls mac-move name vpls26
Virtual Private LAN Service Instance: vpls26, ID:26
Mac Address          Move Count    Elapsed time

90:67:17:e2:46:74    29            00:17:35
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
CLI	Command Line Interface
H-VPLS	Hierarchical Virtual Private LAN Service
IGP	Interior Gateway Protocol
ISIS	Intermediate System to Intermediate System
OSPF	Open Shortest Path First
BFD	Bidirectional Forwarding Detection
VPLS	Virtual Private LAN Service

CHAPTER 12 MAC Limit for VPLS and H-VPLS

Overview

The MAC limit controls how many MAC addresses a system can learn, which is especially beneficial in Virtual Private LAN Service (VPLS) deployments. This control allows you to limit MAC addresses at more granular levels, such as the Access Circuit (AC) or Spoke-PW level, while maintaining the current VPLS instance-level limits.

Characteristics of MAC Move Protection - VPLS/H-VPLS

- Threshold-based control for the number of MAC addresses.
- Granular configuration options, including interface/subinterface/AC/Spoke-PW levels.
- Monitoring and enforcement with actions like logging or error-disable.
- Security benefits by preventing MAC flooding and limiting device access.
- Non-disruptive operation with logging, and optional error-disable with recovery options.

Benefits

- Prevents MAC flooding attacks, controls access to network segments.
- Improves network efficiency by managing memory and CPU usage.
- Granular configuration at interface, subinterface, AC, and Spoke-PW levels.
- Prevents MAC table overflows, ensuring stable traffic forwarding.
- Syslog alerts and watermark thresholds for proactive management.
- Logging doesn't affect traffic, and error-disable includes recovery options.
- Helps networks grow efficiently without overloading devices.

Prerequisites

- **Define Interfaces and Loopback Addresses:**

  Configure Layer 2 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connec-tivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128

interface xe14
 ip address 30.1.1.2/24
```

- **Configure IGP for Dynamic Routing:** Enable ISIS to facilitate dynamic routing on all nodes within the net-work. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution.Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

- **ISIS Configuration:**

```
router isis 1
 is-type level-2-only
 metric-style wide
 microloop-avoidance level-2
 mpls traffic-eng router-id 2.2.2.2
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
      bfd all-interfaces
 net 49.0000.0000.0002.00
 passive-interface lo
!
interface xe14
 mpls ldp-igp sync isis level-2
 isis network point-to-point
 ip router isis 1
```

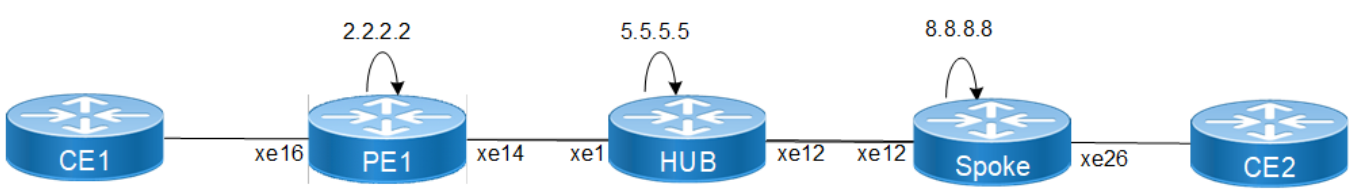
- **OSPF Configuration:**

```
router ospf 1
ospf router-id 2.2.2.2
network 2.2.2.2/32 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0!
!
interface xe14
ip ospf network point-to-point
```

Configuration

Topology

The sample topology for MAC Limit with CE-PE-Hub-Spoke architecture.



MAC Limit for H-VPLS Topology Diagram

Configuring MAC-Limit

Configure PE1 router as follows:

1. Configure router LDP.

```
PE1(config)#router ldp
PE1(config-router)# router-id 2.2.2.2
PE1(config-router)# transport-address ipv4 2.2.2.2
```

2. Configure targeted-peer under router LDP.

```
PE1(config-router)# targeted-peer ipv4 5.5.5.5
PE1(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
PE1(config)#interface xe14
PE1(config-if)# enable-ldp ipv4
PE1(config-if)#label-switching
```

4. Configure VPLS instance.

```
PE1(config)#mpls vpls vpls2000 2000
PE1(config-vpls)# signaling ldp
PE1(config-vpls-sig)#  vpls-peer 5.5.5.5
PE1(config-vpls-sig)#  exit-signaling
PE1(config-vpls)# exit-vpls
PE1(config)#
```

5. Configure sub-interface and attach vpls-instance to sub-interface.

```
PE1(config)#
PE1(config)#interface xe16.2000 switchport
PE1(config-if)# encapsulation dot1q 2000
PE1(config-if)# access-if-vpls
PE1(config-acc-if-vpls)#  mpls-vpls vpls2000
PE1(config-acc-if-vpls)#
```

6. Configure mac-limit profile configuration.

```
PE1(config)#
PE1(config)#vpls mac-limit-profile prof1
PE1(config-vpls-mac-lim-profile)#  learning-limit 5
PE1(config-vpls-mac-lim-profile)#  action log-errdisable
PE1(config-vpls-mac-lim-profile)#  errdisable-timeout 120
```

7. Configure mac-limit profile under AC sub-interface.

```
PE1(config)#
PE1(config)#interface xe16.2001 switchport
PE1(config-if)# access-if-vpls
PE1(config-acc-if-vpls)#learning limit prof1
PE1(config-acc-if-vpls)#exit
```

Configure the MAC-LIMIT on Hub Router:

1. Configure router LDP.

```
Hub(config)#router ldp
Hub(config-router)# router-id 5.5.5.5
Hub(config-router)# transport-address ipv4 5.5.5.5
```

2. Configure targeted-peer under router LDP.

```
Hub(config-router)# targeted-peer ipv4 2.2.2.2
Hub(config-router-targeted-peer)#  exit-targeted-peer-mode
R5-P5(config-router)# targeted-peer ipv4 8.8.8.8
R5-P5(config-router-targeted-peer)#
```

3. Enable LDP and label-switching for core interface.

```
Hub(config)#interface xe1
```

```
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching
Hub(config)#interface xe12
Hub(config-if)# enable-ldp ipv4
Hub(config-if)#label-switching
```

4. Configure VPLS instance.

```
Hub(config)#mpls vpls vpls2000 2000
Hub(config-vpls)# signaling ldp
Hub(config-vpls-sig)#  vpls-peer 2.2.2.2
Hub(config-vpls-sig)#  exit-signaling
Hub(config-vpls)# exit-vpls
Hub(config)#
```

5. Configure L2-ckt.

```
Hub (config)#mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
Hub (config-pseudowire)#
```

6. Attach L2-ckt under vpls instance.

```
Hub (config)#mpls vpls vpls2000 2000
Hub (config-vpls)#vpls-vc vc2000
Hub(config-vpls-spoke)#
```

7. Configure mac-limit profile configuration.

```
HUB(config)#vpls mac-limit-profile prof1
HUB(config-vpls-mac-lim-profile)#  learning-limit 5
HUB(config-vpls-mac-lim-profile)#  action log-errdisable
HUB(config-vpls-mac-lim-profile)#  errdisable-timeout 120
HUB(config-vpls-mac-lim-profile)#
```

8. Configure mac-limit profile under vpls instance.

```
HUB(config)#mpls vpls vpls2001 2001
HUB(config-vpls)#vpls-vc vc2000
HUB(config-vpls-spoke)#  learning limit prof1
HUB(config-vpls-spoke)#
```

Configure the MAC-LIMIT on Spoke Router:

1. Configure router LDP.

```
Spoke(config)#router ldp
Spoke(config-router)# router-id 8.8.8.8
Spoke(config-router)# transport-address ipv4 8.8.8.8
```

2. Configure targeted-peer under router LDP.

```
Spoke(config-router)# targeted-peer ipv4 5.5.5.5
Spoke(config-router-targeted-peer)#  exit-targeted-peer-mode
```

3. Enable LDP and label-switching for core interface.

```
Spoke(config)#interface xe12
Spoke(config-if)# enable-ldp ipv4
Spoke(config-if)#label-switching
```

4. Configure VPLS instance.

```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#
```

5. Configure L2-ckt.

```
Spoke(config)#mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
```

```
Spoke(config-pseudowire)#
```

6. Attach L2-ckt under VPLS instance.

```
Spoke (config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)#
```

7. Configure sub-interface and attach vpls-instance to sub-interface.

```
Spoke(config)#
Spoke(config)#interface xe26.2000 switchport
Spoke(config-if)# encapsulation dot1q 2000
Spoke(config-if)# access-if-vpls
Spoke(config-acc-if-vpls)#  mpls-vpls vpls2000
Spoke(config-acc-if-vpls)#
```

8. Configure mac-limit profile configuration.

```
Spoke(config)#vpls mac-limit-profile R8
Spoke(config-vpls-mac-lim-profile)#  learning-limit 10
Spoke(config-vpls-mac-lim-profile)#  action log-errdisable
Spoke(config-vpls-mac-lim-profile)#  errdisable-timeout 60
Spoke(config-vpls-mac-lim-profile)#
Spoke(config-vpls-mac-lim-profile)#
```

9. Configure mac-limit profile under vpls instance.

```
Spoke(config)#mpls vpls vpls2000 2000
Spoke(config-vpls)#vpls-vc vc2000
Spoke(config-vpls-spoke)#learning limit R8
Spoke(config-vpls-spoke)#
```

Running Configuration on PE1 Router:

```
vpls mac-limit-profile prof1
  learning-limit 5
  action log-errdisable
  errdisable-timeout 120
!

router ldp
 router-id 2.2.2.2
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 2.2.2.2
!
interface xe14
     enable-ldp ipv4
!
mpls vpls vpls2000 2000
 signaling ldp
  vpls-peer 5.5.5.5
  exit-signaling
 exit-vpls
!
interface xe16.2000 switchport
 access-if-vpls
  mpls-vpls vpls2000
  learning limit prof1
```

Running Configuration on Hub Router:

```
vpls mac-limit-profile prof1
  learning-limit 5
  action log-errdisable
  errdisable-timeout 120
!

router ldp
targeted-peer ipv4 2.2.2.2
exit-targeted-peer-mode
 targeted-peer ipv4 8.8.8.8
  exit-targeted-peer-mode
!
!
mpls l2-circuit vc2000 2222 8.8.8.8 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
learning limit prof1
  exit-spoke
 signaling ldp
  vpls-peer 2.2.2.2
  exit-signaling
 exit-vpls
```

Running Configuration on Spoke Router:

```
vpls mac-limit-profile R8
  learning-limit 10
  action log-errdisable
  errdisable-timeout 60
!

router ldp
 router-id 8.8.8.8
 targeted-peer ipv4 5.5.5.5
  exit-targeted-peer-mode
 transport-address ipv4 8.8.8.8
!
mpls l2-circuit vc2000 2222 5.5.5.5 mode raw
!
mpls vpls vpls2000 2000
 vpls-vc vc2000
learning limit R8
  exit-spoke
 exit-vpls
!
interface xe26.2000 switchport
 access-if-vpls
    mpls-vpls vpls2000
```

Validation

Verify vpls mesh are up between PE and Hub

```
PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol   Status     UpTime
2000       5.5.5.5           31364         28162      xe14           26883
2/Up      4          LDP           Active     2d10h36m

Hub#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX SIG-Protocol   Status     UpTime
2000       2.2.2.2           29446         26883           xe1        28162
2/Up      3          LDP           Active     2d10h39m
```

Verify VPLS spoke are up between Hub and Spoke

```
Hub#show ldp mpls-l2-circuit
Transport   Client    VC      VC            Local     Remote    Destination
Lo-cal                         Remote
VC ID      Binding    State    Type          VC Label  VC Label  Address
PW Status                     PW Status
2222       VPLS:2000  UP       Ethernet      26882     26886     8.8.8.8
Forwarding                    Forwarding

Hub#sho mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St   Secondary
2000       vc2000           29443         26882      ce4            26886
2/Up
    ---

Spoke#show ldp mpls-l2-circuit
Transport   Client    VC      VC            Local     Remote    Destination
Lo-cal                         Remote
VC ID      Binding    State    Type          VC Label  VC Label  Address
PW Status                     PW Status
2222       VPLS:2000  UP       Ethernet      26886     26882     5.5.5.5
Forwarding                    Forwarding

Spoke#show mpls vpls spoke
VPLS-ID    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-Label
Lkps/St   Secondary
2000       vc2000           29440         26886      ce4            26882
2/Up     ---
```

Verify MAC-LIMIT session on Hub and spoke:

```
Hub#show mpls vpls vpls2000
Virtual Private LAN Service Instance: vpls2000, ID: 2000
 SIG-Protocol: LDP
 Attachment-Circuit: UP
```

```
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, VPLS Type: Ethernet, Configured MTU: 1500
Description: none
service-tpid: dot1.q
Operating mode: Raw
Ignoring AC interface and spoke-VC state

Configured interfaces:
  None

Mesh Peers:
  2.2.2.2 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d10h47m)
  3.3.3.3 (Peer VPLS Type: Ethernet) (Up) (UpTime: 2d10h56m)
Spoke Peers:
  vc2000 (Up) (UpTime 00:05:48)
```

CLI Commands

The MAC Limit introduces the following configuration commands.

vpls mac-limit-profile

Use this command to set the MAC address learning limits which will be used to associate the AC or Spoke PW for a specific VPLS MAC limit profile.

Use `no` parameter of this command to delete the VPLS MAC limit profile.

Command Syntax

```
vpls mac-limit-profile <PROFILE_NAME> learning-limit <1-32767> | high-watermark <1-
  100> | low-watermark <1-100> | action (log-errdisable <0-86400> | log-only) |
  errdisable-timeout <0-86400>
no vpls mac-limit-profile
```

Parameters

`<PROFILE_NAME>`	Specifies the name of the MAC limit profile.
`learning-limit <1-32767>`	Specifies the maximum number of MAC addresses allowed to be learned on the interface. The default value is 32767.
`high-watermark <1-100>`	Specifies the high watermark (maximum number of MAC addresses) for logging purposes. The threshold is a numeric value and a percentage of the learning limit. The default value is 90%.
`low-watermark <1-100>`	Specifies the low watermark (minimum number of MAC addresses) for logging purposes. The threshold is a numeric value and a percentage of the learning limit. The default value is 70%.

action log-errdisable <0-86400>	Logs an event when the MAC limit is exceeded and disables MAC learning for the timeout period.The default value is 0.
action log-only	Logs when the MAC limit is exceeded without disabling MAC learning.
errdisable-timeout <0-86400>	Specifies the duration (in seconds) before MAC learning is re-enabled after being errdisabled. The default value is 0, meaning no automatic recovery.

Default

None

Command Mode

VPLS MAC Limit Profile Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

The following example is for creating a VPLS MAC limit profile and configuring with specific parameters to manage MAC address learning limits:

```
#configure terminal
(config)#vpls mac-limit-profile prof1
(config-vpls-mac-lim-profile)#learning-limit 50
(config-vpls-mac-lim-profile)#action log-errdisable
(config-vpls-mac-lim-profile)#high-watermark 60
(config-vpls-mac-lim-profile)#low-watermark 30
(config-vpls-mac-lim-profile)#errdisable-timeout 30
(config-vpls-mac-lim-profile)#commit
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

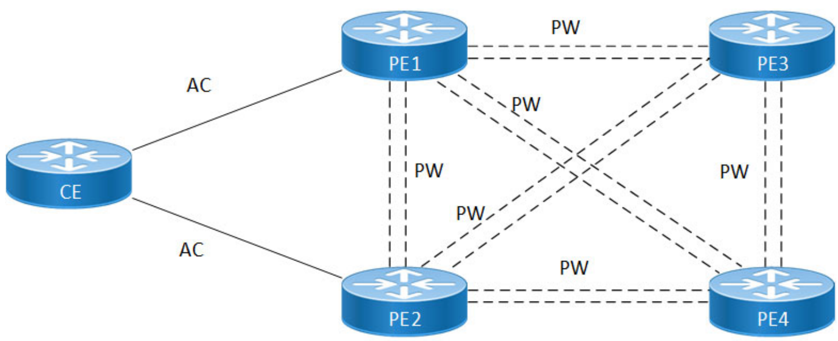
Key Terms/Acronym	Description
CLI	Command Line Interface
H-VPLS	Hierarchical Virtual Private LAN Service
IGP	Interior Gateway Protocol
ISIS	Intermediate System to Intermediate System
OSPF	Open Shortest Path First
BFD	Bidirectional Forwarding Detection
VPLS	Virtual Private LAN Service

CHAPTER 13 MLAG Active-Standby for VPLS

Overview

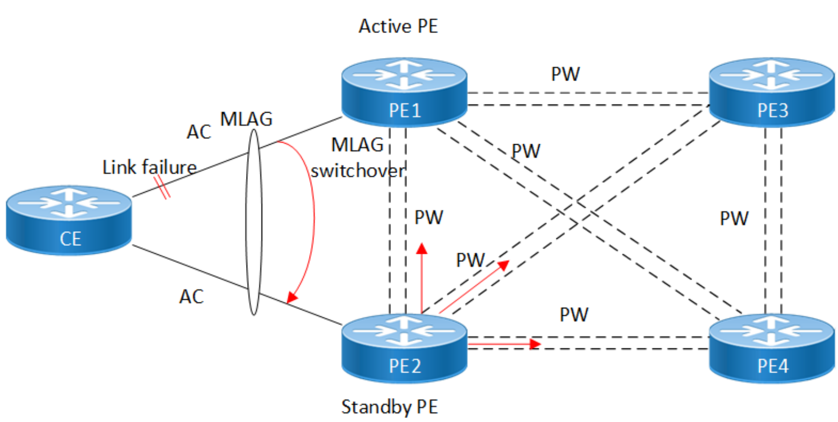
The Virtual Private LAN Service (VPLS) architecture provides a multipoint ethernet connection using the Multi-Protocol Label Switching (MPLS) transport. This helps connect multiple devices from different geographical locations to the same virtual network. The Multi-Chassis Link Aggregation (MLAG) provides the redundancy technique in the VPLS architecture, making it failsafe multipoint VPLS connectivity. The redundancy in the network traffic is achieved by dual-homing a Customer Edge (CE) device to two Provider Edge (PE) devices.

A single CE is dual-homed to two PEs for redundancy is shown in the following figure:



Feature Characteristics

The Multi-Chassis Link Aggregation (MLAG) Active-Standby for VPLS feature facilitates implementation of the MLAG Active-Standby between the VPLS PE devices. This facilitates Attachment Circuit (AC) redundancy for the dual-homed Customer Edge (CE) device. This means there is one Active link and another Standby link between a CE device and the PE devices. When an Active link fails, the Standby link becomes Active with the MLAG switch, resulting in a change in topology. The change in topology requires a mac-flush in the peer devices for faster convergence. The feature also facilitates forwarding the automatic mac-flush message to all the peer nodes, reducing the convergence time when a link fails.



The above figure shows a VPLS mesh linked to a dual-homed CE connected to PE1 and PE2. The traffic flows from CE to PE3 through the active MLAG PE1, while PE2 remains a standby MLAG. When PE1 experiences a link failure, the standby MLAG becomes active, and traffic flows through the PE2 device to reach the destination PE3. Configuring the `mac flush send on mlag switchover` command enables MAC flush PDU tx, and PE2 automatically sends the MAC flush message to all the peer nodes PE1, PE3, and PE4 as depicted by the red arrows, which reduces the convergence time.

Consider the following point while configuring this feature:

- Only Active-Standby MLAG is supported.
- Only flush-all-but-mine MAC-flush approach is supported.
- If multiple Attachment Circuits (ACs) are mapped to the same MLAG interface, the MLAG switch is not triggered when only one or a few AC go down.
- MAC flush on a remote VPLS peer is supported only when LDP signaling (not BGP signaling) is used. A MAC flush message (flush-all-but-mine) will have an empty MAC address list. An empty MAC address list will flush all the MAC addresses and cannot flush any selected MAC addresses.

Benefit

This feature enhances the reliability of VPLS by providing redundancy using MLAG.

Prerequisites

Refer to the MLAG Configuration section in the *OcNOS Layer 2 Guide*.

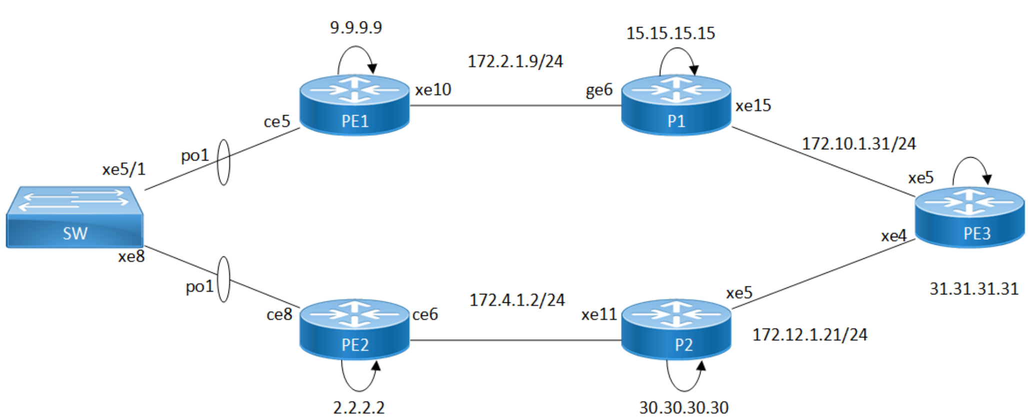
Configuration

This section shows the configuration of the MLAG VPLS.

Topology

The following topology shows a VPLS mesh. The traffic is flowing from SW to PE3. PE1 has an MLAG configured as Active and PE2 as Standby. When a link failure occurs between SW and PE1 (the Active MLAG node), the link between SW and PE2 becomes Active.

Figure 13-27: MLAG VPLS configuration topology



MLAG VPLS Configuration

The following steps show the configuration of the MLAG VPLS with automatic MAC flush capability during the MLAG switchover.

Configuring MLAG on PE1 (Active) and PE2 (Standby)

1. Type `bridge 1 protocol rstp vlan-bridge` to create a bridge and attach it to the RSTP. Type the command `vlan database` to enter the VLAN configuration mode, and then `vlan 100-300 bridge 1 state enable` to enable the VLAN 100 to 300 on the bridge 1.

```
(config)#bridge 1 protocol rstp vlan-bridge
(config)#vlan database
(config-vlan)#vlan 100-300 bridge 1 state enable
```

2. Type `mcec domain configuration` to enter the MCEC domain configuration mode and then configure the `domain-address` to identify the MCEC domain. Type the command `domain-system-number 1` to configure the domain system number that uniquely identifies the domain system in MCEC domain and then type the command `intra-domain-peer 2.2.2.2 source-address 9.9.9.9` to map an interface as intra domain peer that connects the domain system with its neighbor in a MCEC domain.

```
(config)#mcec domain configuration
(config-mcec-domain)#domain-address 1111.2222.3333
(config-mcec-domain)#domain-system-number 1
(config-mcec-domain)#intra-domain-peer 2.2.2.2 source-address 9.9.9.9
```

3. Type the command `interface mlag1` and then `switchport` to configure the interface. Type `bridge-group 1` to bind an interface with the bridge group. Type `switchport mode trunk` to set the interface to the trunk port that allows multiple VLAN configurations in the interface, and then type `switchport trunk allowed vlan add 100-150` to configure the required VLAN identifier. Type the command `switchover type revertive 2` to return back to initial MLAG after 2 seconds after fail recovery.

```
(config)#interface mlag1
(config-if)#switchport
(config-if)#bridge-group 1
(config-if)#switchport mode trunk
(config-if)#switchport trunk allowed vlan add 100-150
(config-if)#switchover type revertive 2
```

4. Type `interface po1` to enter the specified port channel, type `switchport` to configure the interface as Layer 2, and the type `mlag 1` to enable the specific MLAG.

```
(config)#interface po1
(config-if)#switchport
(config-if)#mlag 1
```

5. Type `interface ce5` to configure the interface and then type `channel-group 1 mode active` to add the interface to the channel group.

```
(config)#interface ce5
(config-if)#channel-group 1 mode active
```

Configuring VPLS Session on PE1 (Active MLAG Peer), PE2 (Standby MLAG Peer), and PE3

1. Type `mpls vpls vpls1 200` to create an VPLS instance. Type `mac-flush-send-on-mlag-switchover` to enable the MAC flush PDU tx during the MLAG switchover, type `signaling ldp` to enter the VPLS signaling mode as only LDP signaling is supported for the MAC flush, and then type `vpls-peer 2.2.2.2` and `vpls-peer 31.31.31.31` to add a peer to a VPLS domain.

```
(config)#mpls vpls vpls1 200
(config-vpls)#mac-flush-send-on-mlag-switchover
(config-vpls)#signaling ldp
```

```
(config-vpls-sig)#vpls-peer 2.2.2.2
(config-vpls-sig)#vpls-peer 31.31.31.31
(config-vpls-sig)#exit-signaling
(config-vpls)#exit-vpls
```

2. Type `interface po1.200 switchport` to create a sub-interface. In the sub-interface, type `encapsulation dot1q 200` to select the type of encapsulation as dot1q with the VLAN ID 200. Type `access-if-vpls` to create a VPLS access port and then `mpls-vpls vpls1` to bind the VPLS instance to the subinterface.

```
(config)#interface po1.200 switchport
(config-if)#encapsulation dot1q 200
(config-if)#access-if-vpls
(config-acc-if-vpls)#mpls-vpls vpls1
```

Running configurations

PE1:

```
bridge 1 protocol rstp vlan-bridge
vlan database
 vlan 100-300 bridge 1 state enable

mcec domain configuration
 domain-address 1111.2222.3333
 domain-system-number 1
 intra-domain-peer 2.2.2.2 source-address 9.9.9.9


interface mlag1
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan add 100-150
 switchover type revertive 2

interface po1
 switchport
  mlag 1

mpls vpls vpls1 200
 mac-flush-send-on-mlag-switchover
 signaling ldp
  vpls-peer 2.2.2.2
  vpls-peer 31.31.31.31
  exit-signaling
 exit-vpls

interface po1.200 switchport
 encapsulation dot1q 200
 access-if-vpls
  mpls-vpls vpls1


interface ce5
 channel-group 1 mode active
!
```

PE2:

```
bridge 1 protocol rstp vlan-bridge

vlan database
 vlan 100-300 bridge 1 state enable

mcec domain configuration
 domain-address 1111.2222.3333
 domain-system-number 1
 intra-domain-peer 9.9.9.9 source-address 2.2.2.2


interface mlag1
 switchport
 bridge-group 1
 switchport mode trunk
 switchport trunk allowed vlan add 100-150
 switchover type revertive 2

interface po1
 switchport
  mlag 1

mpls vpls vpls1 200
 mac-flush-send-on-mlag-switchover
 signaling ldp
  vpls-peer 9.9.9.9
  vpls-peer 31.31.31.31
  exit-signaling
 exit-vpls

interface po1.200 switchport
 encapsulation dot1q 200
 access-if-vpls
  mpls-vpls vpls1

!
interface ce8
 speed 40g
 channel-group 1 mode active
!
```

PE3:

```
mpls vpls vpls1 200
 mac-flush-send-on-mlag-switchover
 signaling ldp
  ignore-ac-spoke-state
  vpls-peer 2.2.2.2
  vpls-peer 9.9.9.9
  exit-signaling
 exit-vpls
!
interface xe8.200 switchport
 encapsulation dot1q 200
 access-if-vpls
  mpls-vpls vpls1
```

```
!
```

Validation

Use the following show commands to verify the configuration.

Verify MLAG Domain summary on PE1 and PE2 to verify the Current MLAG status and MLAG Synchronization

```
PE1# #show mlag domain summary

------------------------------------
Domain Configuration
------------------------------------

Domain System Number            : 1
Domain Address                  : 1111.2222.3333
Domain Priority                 : 32768
Source Address                  : 9.9.9.9
Intra-domain-peer               : 2.2.2.2
Domain Adjacency                : UP
MCEC PDU local version          : 1
MCEC PDU peer version           : 1
Domain Sync via                : Intra-domain-peer

------------------------------------
MLAG Configuration
------------------------------------

MLAG-1
  Mapped Aggregator            : po1
  Physical properties Digest   : 54 a9 3a 2a 2b 50 65 bb 3c bc 3d bd c2 43 d6 22
  Total Bandwidth              : 40g
  Mlag Sync                    : IN_SYNC
  Mode                         : Active-Standby
  Current Mlag state           : Active
  Switchover-mode              : Revertive (2s)


PE2#show mlag domain summary

------------------------------------
Domain Configuration
------------------------------------

Domain System Number            : 2
Domain Address                  : 1111.2222.3333
Domain Priority                 : 32768
Source Address                  : 2.2.2.2
Intra-domain-peer               : 9.9.9.9
```

```
Domain Adjacency                : UP
MCEC PDU local version          : 1
MCEC PDU peer version           : 1
Domain Sync via                : Intra-domain-peer

------------------------------------
MLAG Configuration
------------------------------------

MLAG-1
  Mapped Aggregator             : po1
  Physical properties Digest    : 54 a9 3a 2a 2b 50 65 bb 3c bc 3d bd c2 43 d6 22
  Total Bandwidth               : 40g
  Mlag Sync                     : IN_SYNC
  Mode                          : Active-Standby
  Current Mlag state            : Standby
  Switchover-mode               : Revertive (2s)
  Revert Timer                  : OFF
```

Verify VPLS sessions on PE1, PE2, and PE3

```
PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime     Ext-Color
200        2.2.2.2                              24323         25608      xe10
25608        2/Up                 1         LDP             Active     00:20:29      -
200       31.31.31.31                   24325        25604     xe10         26885
2/Up                  2          LDP             Active     00:20:29      -

PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime     Ext-Color
200       9.9.9.9                        N/A       25608     N/A          25608
0/Dn                  3          LDP             Standby     -   -
200       31.31.31.31                  N/A       25602     N/A           26890
0/Dn                  4          LDP             Standby     -   -

PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol         Status     UpTime     Ext-Color
200       2.2.2.2                           N/A            26885      N/A
25604        0/Dn                  2         LDP              Standby    -   -
```

```
200       9.9.9.9                          24320        26890      xe4
25602       2/Up                     1          LDP              Active     17:35:59   -
```

Verify VPLS MAC addresses learned on PE1, PE2, and PE3

```
PE1#show mpls vpls mac-address
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID     MAC address       Learned from                          Vlan-Id          Peer
address   Time-out  Move Count
200       0000.2000.0020   xe10                                -              31.31.31.31
300         0
200         0010.2000.0020    po1.200

PE2#show mpls vpls mac-address
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID     MAC address       Learned from                          Vlan-Id          Peer
address   Time-out  Move Count
200       0000.2000.0020   xe10                                -              31.31.31.31
300         0

PE3#show mpls vpls mac-address
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID     MAC address       Learned from                          Vlan-Id          Peer
address   Time-out  Move Count
200         0000.2000.0020    xe8.200
200       0010.2000.0020   xe5                                 -              9.9.9.9
296         0
```

MLAG Active peer went down (Shutdown Acive MLAG peer interface on PE1 or on switch)

```
PE1(config)#interface po1
PE1(config-if)#shutdown
PE1(config-if)#commit
PE1(config)#end
```

Verify MLAG domain summary on PE1 and PE2 to verify the Current MLAG status and MLAG Synchronization

```
PE1#show mlag domain summary

------------------------------------
Domain Configuration
------------------------------------
```

```
Domain System Number            : 1
Domain Address                  : 1111.2222.3333
Domain Priority                 : 32768
Source Address                  : 9.9.9.9
Intra-domain-peer               : 2.2.2.2
Domain Adjacency                : UP
MCEC PDU local version          : 1
MCEC PDU peer version           : 1
Domain Sync via                : Intra-domain-peer

------------------------------------
MLAG Configuration
------------------------------------

MLAG-1
  Mapped Aggregator            : po1
  Physical properties Digest   : 54 a9 3a 2a 2b 50 65 bb 3c bc 3d bd c2 43 d6 22
  Total Bandwidth              : 40g
  Mlag Sync                    : IN_SYNC
  Mode                         : Active-Standby
  Current Mlag state           : Standby
  Switchover-mode              : Revertive (2s)

PE2#show mlag domain summary

------------------------------------
Domain Configuration
------------------------------------

Domain System Number            : 2
Domain Address                  : 1111.2222.3333
Domain Priority                 : 32768
Source Address                  : 2.2.2.2
Intra-domain-peer               : 9.9.9.9
Domain Adjacency                : UP
MCEC PDU local version          : 1
MCEC PDU peer version           : 1
Domain Sync via                : Intra-domain-peer

------------------------------------
MLAG Configuration
------------------------------------

MLAG-1
  Mapped Aggregator            : po1
  Physical properties Digest   : 54 a9 3a 2a 2b 50 65 bb 3c bc 3d bd c2 43 d6 22
  Total Bandwidth              : 40g
  Mlag Sync                    : IN_SYNC
  Mode                         : Active-Standby
```

```
 Current Mlag state           : Active
 Switchover-mode              : Revertive (10s)
 Revert Timer                 : OFF
```

Verify VPLS sessions on PE1, PE2, and PE3

```
PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime     Ext-Color
200       2.2.2.2                         N/A         25608     N/A          25608
0/Dn                 1         LDP              Standby     -   -
200        31.31.31.31                  N/A         25604     N/A          26885
0/Dn                 2         LDP              Standby     -   -

PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime     Ext-Color
200        9.9.9.9          24321         25608      ce6            25608      2/Up
3         LDP           Active     00:21:54      -
200        31.31.31.31      24325         25602      ce6            26890      2/Up
4         LDP           Active     17:35:21      -

PE3#show mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime     Ext-Color
200        2.2.2.2          24320         26890      xe4            25602      2/Up
1         LDP           Active     17:45:58   -
200        9.9.9.9          N/A           26885      N/A            25604      0/Dn
2         LDP           Standby     -   -
```

Verify VPLS MAC addresses learned on PE1, PE2, and PE3

```
PE1#show mpls vpls mac-address
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID     MAC address       Learned from                      Vlan-Id          Peer
address   Time-out  Move Count
200        0000.2000.0020   xe10                          -             31.31.31.31
300          0
```

```
PE2#show mpls vpls mac-address
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID     MAC address       Learned from                           Vlan-Id          Peer
address   Time-out  Move Count
200       0000.2000.0020   xe3                                  -              31.31.31.31
300         0
200         0010.2000.0020    po1.200

PE3#show mpls vpls mac-address
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID     MAC address       Learned from                           Vlan-Id          Peer
address   Time-out  Move Count
200         0000.2000.0020    xe8.200
200       0010.2000.0020   xe4                                  -              2.2.2.2
296         0
```

MLAG Active-Standby for VPLS commands

The MLAG Active-Standby for VPLS introduces the following configuration command.

mac flush send on mlag switchover

Use this command to enable the MAC flush PDU tx during the MLAG switchover.

Use the `no` command to disable the MAC PDU tx flush during the MLAG switchover.

Command Syntax

```
mac-flush-send-on-mlag-switchover
no mac-flush-send-on-mlag-switchover
```

Parameters

None

Default

Disabled

Command Mode

VPLS mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

This example shows how to configure mac flush automatically on the peer nodes:

```
OcNOS#configure terminal
OcNOS(config)#mpls vpls VPLS-102 102
OcNOS(config-vpls)#mac-flush-send-on-mlag-switchover
OcNOS(config-vpls)#commit
OcNOS(config-vpls)#end
```

Revised CLI Commands

The following command is revised:

switchover type

The revertive time range is revised from `<1-255>` to `<1-3600>`. For more details, refer to switchover type command in the Multi-chassis Link Aggregation Commands chapter in the *Layer 2 Guide*.

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
VPLS	Virtual Private Local Area Network Service is a technology that uses a shared Layer 2 Virtual Private Network (L2VPN) to establish communication between different geographical sites as if they are in the same Local Area Network (LAN).
MPLS	Multi-Protocol Label Switching is a high-performance routing protocol that attaches labels to data packets to efficiently forward and route data in a network.
CE	Customer Edge is a device that resides at the customer premises and bridges the customer's internal network to the service provider network.
PE	Provider Edge is a device that resides at the provider's edge, manages traffic from the customer edge, and forwards it to the provider's backbone.
MLAG	Multi-Chassis Link Aggregation is a network architecture that uses multiple switches or routers to work as a single logical device to increase redundancy and bandwidth.
AC	Attachment circuit is an interface or link that connects a CE device to the PE device.
MAC	Media Access Control is a unique identifier of a device's network interface card (NIC) to communicate in a local area network (LAN).

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CHAPTER 14 Virtual Private Wire Service Configuration

This chapter shows configurations for Virtual Private Wire Service (VPWS), where a point-to-point Layer 2 VPN service interconnects multiple Ethernet LANs across an MPLS backbone.

Overview

An MPLS Layer 2 Virtual Circuit (VC) is a point-to-point Layer 2 connection transported via MPLS on the service provider's network. The Layer 2 circuit is transported over a single Label Switched Path (LSP) tunnel between two Provider Edge (PE) routers.

The following diagram illustrates the configuration steps in this section. In this sample, the VC host devices, Host1 and Host2, are connected to the Provider Edge (PE) router PE-1; and Host3 and Host4 are connected to PE-2. The VC is established between PE-1 and PE-2. Interface xe2, on PE-1 and PE-2, is connected to the customer network; xe1, on PE-1 and PE-2, is connected to the MPLS cloud.

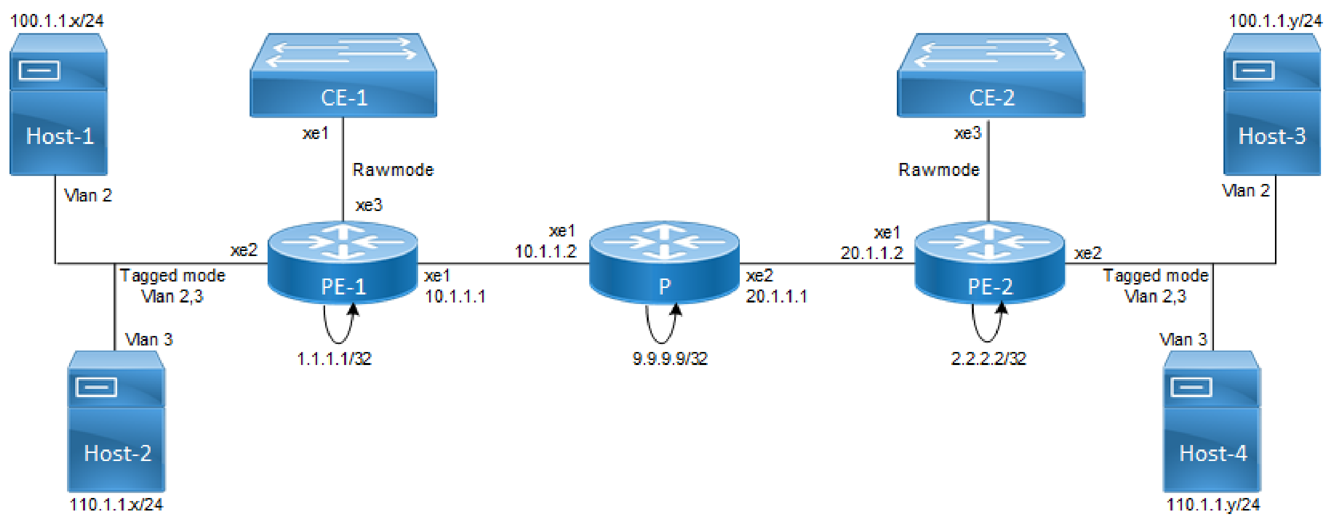

Figure 14-28: MPLS Layer 2 Virtual Circuit

The VC configuration process can be divided into the following steps:

Note: Loopback addresses being used should be advertised through OSPF, or should be statically routed.

1. Configure the IP address and OSPF for the PE-1, P (Provider), and PE-2 routers.
2. Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peer for the PE-1 and PE-2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2.)
3. Configure the VC.
4. Bind the customer interface to the VC.

Configure IP Address and OSPF on Routers

Configure the IP addresses and OSPF on the PE-1, P, and PE-2 routers.

PE-1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to `1.1.1.1/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 10.1.1.1/24`	Set the IP address of the interface to `10.1.1.1/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 10.1.1.0/24 area 0` `(config-router)#network 1.1.1.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface.
`(config-router)#commit`	Commit the transaction.

P

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 9.9.9.9/32 secondary`	Set the IP address of the loopback interface to `9.9.9.9/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 10.1.1.2/24`	Set the IP address of the interface to `10.1.1.2/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Specify the interface `(xe2)` to be configured.
`(config-if)#ip address 20.1.1.1/24`	Set the IP address of the interface to `20.1.1.1/24`.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.

`(config-router)#network 10.1.1.0/24 area 0`
`(config-router)#network 20.1.1.0/24 area 0`
`(config-router)#network 9.9.9.9/32 area 0`
	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface.

`(config-router)#commit`	Commit the transaction.

PE-2

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback interface `(lo0)` to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to `2.2.2.2/32`.
`(config-if)#exit`	Exit interface mode.

(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#ip address 20.1.1.2/24	Set the IP address of the interface to 20.1.1.2/24.
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 20.1.1.0/24 area 0 (config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs, and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

Configure MPLS, LDP, and LDP Targeted Peer on Routers

Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peers on PE-1 and PE-2.

Note: If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2,

PE-1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 2.2.2.2	Specify the targeted LDP peer on PE-1.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1..
(config-if)#commit	Commit the transaction.

P

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)#router-id 9.9.9.9	Set the router ID to IP address 9.9.9.9
(config-router)#transport-address ipv4 9.9.9.9	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.

(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter the Router mode.
(config)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
(config-router)#targeted-peer ipv4 1.1.1.1	Specify the targeted LDP peer on PE-2.
(config-router-targeted-peer)# exit	Exit the Router targeted peer mode.
(config-router)#exit	Exit the Router mode.
(config)#interface xe1	Specify the interface(xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#commit	Commit the transaction.

Configure VC

Configure the VC. Each VC ID uniquely identifies the Layer-2 circuit among all the Layer-2 circuits.

Note: Both PE routers (endpoints) must be configured with the same VC-ID (100 in this example).

PE-1

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t1 100 2.2.2.2	Configure the VC for PE-2. In this example, t1 is the VC name, 100 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
(config)#commit	Save transaction into the database

PE-2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t1 100 1.1.1.1	Configure the VC for PE-1. In this example, t1 is the VC name, 100 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
(config)#commit	Commit the transaction.

Bind Customer Interface to VC

Bind the customer interface to the VC using one of the two procedures described below: Layer-2 untagged traffic or Layer-2 tagged traffic.

Note: Layer 2 VCs can only be bound to Layer 2 interfaces. The VC encapsulation method should be Ethernet (default), VLAN.

Layer 2 Untagged Traffic

Use Access mode for Layer 2 untagged traffic.

PE-1

`#configure terminal`	Enter configure mode.
`(config)#service-template SUT1`	Create a service template SUT1
`(config-svc)#match untagged`	Allow untagged traffic.
`(config-svc)#exit`	Exit the service template mode
`(config)#interface xe3`	Specify the interface (xe3) to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#mpls-l2-circuit t1 service-template SUT1`	Bind the interface to the VC with service template.
`(config-if)#commit`	Commit the transaction.

PE-2

`#configure terminal`	Enter configure mode.
`(config)#service-template SUT1`	Create a service template SUT1
`(config-svc)#match untagged`	Allow untagged traffic.
`(config-svc)#exit`	Exit the service template mode
`(config)#interface xe3`	Specify the interface (xe3) to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#mpls-l2-circuit t1 service-template SUT1`	Bind the interface to the VC with service template.
`(config-if)#commit`	Commit the transaction.

Layer 2 Tagged Traffic

Use Trunk mode for Layer-2 tagged traffic. The following configuration allows only VLAN 2 and 3 traffic.

PE-1

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit t2 200 2.2.2.2`	Configure the VC for PE-2. In this example, t2 is the VC name, 200 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#service-template ST1`	Create a service template ST1
`(config-svc)#match outer-vlan 2`	Allow VLAN 2 traffic on this VC.
`(config-svc)#match outer-vlan 3`	Allow VLAN 3 traffic on this VC.

(config-svc)#exit	Exit the service template mode
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

PE-2

#configure terminal	Enter configure mode.
(config)#mpls l2-circuit t2 200 1.1.1.1	Configure the VC for PE-2. In this example, t2 is the VC name, 200 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template ST1	Create a service template ST1
(config-svc)#match outer-vlan 2	Allow VLAN 2 traffic on this VC.
(config-svc)#match outer-vlan 3	Allow VLAN 3 traffic on this VC.
(config-svc)#exit	Exit the service template mode
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#switchport	Switch to Layer-2 mode.
(config-if)#mpls-l2-circuit t2 service-template ST1	Bind the interface to the VC with service template.
(config-if)#commit	Commit the transaction.

Validation

Use the show ldp mpls-l2-circuit (Control Plane) command, and the show mpls vc-table (Forwarding Plane) command, to display complete information about the Layer 2 VC.

If the VC State is UP in the output from the show ldp mpls-l2 circuit command, and the Status is Active in the output of the show mpls vc-table command, a ping from CE1 to CE2 should be successful.

```
#show ldp mpls-l2-circuit
Transport    Client      VC       Trans    Local        Remote        Destination
VC ID        Binding     State    Type     VC Label     VC Label      Address
100          xe3         UP       Ethernet VLAN 26240   26240         2.2.2.2
200          xe2         UP       Ethernet VLAN 26241   26241         2.2.2.2


#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VC-ID      Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label
Nexthop         Status
100         N/A      N/A            xe3           xe1           26240      25600
2.2.2.2         Active
200         N/A      N/A            xe2           xe1           26241      25600
2.2.2.2         Active
```

```
PE2#show ldp mpls-l2-circuit
Transport Client VC      VC        Local      Remote   Destination
VC ID     Binding State  Type      VC Label   VC Label  Address
100       xe3     UP     Ethernet  VLAN 26240 26240     1.1.1.1
200       xe2     UP     Ethernet  VLAN 26241 26241     1.1.1.1
```

```
PE2#sh mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe3 xe1 26240 25601 1.1.1.1 Active 200 N/A N/A xe2 xe1 26241 25601 1.1.1.1 Active
```

```
PE1#show ldp mpls-l2-circuit
Transport   Client   VC      VC       Local        Remote       Destination
VC ID       Binding  State  Type      VC Label     VC Label     Address
100         xe3      UP     Ethernet  VLAN 26240   26240        2.2.2.2
200         xe2      UP     Ethernet  VLAN 26241   26241        2.2.2.2
```

```
PE1#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe3 xe1 26240 25600 2.2.2.2 Active 200 N/A N/A xe2 xe1 26241 25600 2.2.2.2 Active
```

```
PE2#show ldp mpls-l2-circuit
Transport  Client VC        VC        Local        Remote      Destination
VC ID      Binding State    Type      VC Label     VC Label    Address
100        xe3      UP      Ethernet  VLAN 26240   26240       1.1.1.1
200        xe2      UP      Ethernet  VLAN 26241   26241       1.1.1.1
```

```
PE2#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
VC-ID Vlan-ID Inner-Vlan-ID Access-Intf Network-Intf Out Label Tunnel-Label Nexthop Status
100 N/A N/A xe3 xe1 26240 25601 1.1.1.1 Active 200 N/A N/A xe2 xe1 26241 25601 1.1.1.1 Active
```

These additional commands can also be used to display information about the Layer 2 virtual circuits.

```
show ldp mpls-l2-circuit detail
show ldp mpls-l2-circuit VC-ID
show ldp mpls-l2-circuit VC-ID detail
show mpls l2-circuit
```

PE1

```
PE1#show ldp mpls-l2-circuit detail
PW ID: 100, VC state is up
Access IF: xe3,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26240, remote label: 26240
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow
```

```
Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:03:19

PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:01:16

PE1#show ldp mpls-l2-circuit 100
Transport  Client  VC    VC        Local        Remote   Destination
VC ID      Binding State Type      VC Label     VC Label Address
100        xe3      UP    Ethernet VLAN 26240   26240    2.2.2.2

PE1#show ldp mpls-l2-circuit 200
Transport  Client  VC  VC     Local   Remote   Destination
VC ID    Binding  State Type    VC Label VC Label  Address
200     xe2    UP  Ethernet VLAN 26241   26241   2.2.2.2

PE1#show ldp mpls-l2-circuit
100 detail PW ID: 100, VC state is up
Access IF: xe3,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26240, remote label: 26240
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:04:19

PE1#show ldp mpls-l2-circuit 200 detail
```

```
PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow
Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled MPLS VC UpTime : 00:02:24

PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t1, id: 100 PW-INDEX: 1 service-tpid: dot1.q
 Endpoint: 2.2.2.2
 Control Word: 0
 Flow Label Status: Disabled, Direction: None, Static: No
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe3
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : SUT1
 Match criteria : Untagged

MPLS Layer-2 Virtual Circuit: t2, id: 200 PW-INDEX: 2 service-tpid: dot1.q
 Endpoint: 2.2.2.2
 Control Word: 0
 Flow Label Status: Disabled, Direction: None, Static: No
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe2
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : ST1
 Match criteria : 2,3
```

PE2

```
PE2#show ldp mpls-l2-circuit detail
PW ID: 100, VC state is up
Access IF: xe3,up,AC state is up
Session IF: xe1, state is up
Destination: 1.1.1.1, Peer LDP Ident: 10.143.73.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
```

```
Local label: 26240, remote label: 26240
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled MPLS VC UpTime : 00:07:08

PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 1.1.1.1, Peer LDP Ident: 10.143.73.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:05:05

PE2#show ldp mpls-l2-circuit 100
Transport  Client   VC      VC      Local       Remote     Destination
VC ID      Binding  State   Type     VC Label    VC Label  Address
100        xe3       UP     Ethernet VLAN 26240   26240    1.1.1.1

PE2#show ldp mpls-l2-circuit 200
Transport  Client   VC      VC      Local          Remote   Destination
VC ID      Binding  State   Type     VC Label VC  Label    Address
200        xe2       UP     Ethernet VLAN 26241   26241    1.1.1.1

PE2#show ldp mpls-l2-circuit
PW ID: 200, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 1.1.1.1, Peer LDP Ident: 10.143.73.1
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 26241, remote label: 26241
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled Remote Control Word: Not-Applicable Current use: disabled
Local Flow Label Direction: Disabled, Static: Disabled
Remote Flow Label Direction: Disabled, Static: Disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled
MPLS VC UpTime : 00:06:00
```

```
PE2#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: t1, id: 100 PW-INDEX: 1 service-tpid: dot1.q
 Endpoint: 1.1.1.1
 Control Word: 0
 Flow Label Status: Disabled, Direction: None, Static: No
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe3
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : SUT1
 Match criteria : Untagged

MPLS Layer-2 Virtual Circuit: t2, id: 200 PW-INDEX: 2 service-tpid: dot1.q
 Endpoint: 1.1.1.1
 Control Word: 0
 Flow Label Status: Disabled, Direction: None, Static: No
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe2
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : ST1
Match criteria : 2,3
```

Configure a Static Layer-2 VC

For a static MPLS Layer 2 VC configuration:

1. Configure the VC with the manual option
2. Configure the VC FIB entry
3. Bind the VC; all steps are in the configurations that follow.

PE-1

`#configure terminal`	Enter configure mode.
`PE1(config)#mpls l2-circuit t3 300 2.2.2.2`	Configure the VC ID for PE1
`PE1(config-pseuodwire)#manual-pseudowire`	Configure pseudowire manual (no signaling)
`PE1(config-pseudowire)#exit`	Exit pseudowire config mode.
`PE1(config)#service-template ST3`	Create a service template ST3
`PE1(config-svc)#exit`	Exit the service template mode
`PE1(config)#interface xe2`	Add an FTN entry; where 1000 is the incoming label, 2000 is the outgoing label, 2.2.2.2 is the endpoint, xe1 is the incoming interface name, and xe2 is outgoing interface name.

`PE1(config)#switchport`	config interface as switch port.
`PE1(config-if)#mpls-l2-circuit t3 service-template ST3`	Bind the interface to the VC with service template.
`PE1(config-if)#exit`	Exit interface mode
`PE1(config)#mpls l2-circuit-fib-entry 300 1000 2000 2.2.2.2 xe1 xe2`	Configure the VC ID with the manual option (no signaling used).
`PE1(config)#commit`	Commit the transaction.

PE-2

`#configure terminal`	Enter configure mode.
`PE2(config)#mpls l2-circuit t3 300 1.1.1.1`	Configure the VC ID for PE2
`PE2(config-pseuodwire)#manual-pseudowire`	Configure pseudowire manual (no signaling)
`PE2(config-pseudowire)#exit`	Exit pseudowire config mode.
`PE2(config)#service-template ST3`	Create a service template ST3
`(config-svc)#exit`	Exit the service template mode
`PE2(config)#interface xe2`	Add an FTN entry; where 2000 is the incoming label, 1000 is the outgoing label, 1.1.1.1 is the endpoint, xe1 is the incoming interface name, and xe 2 is outgoing interface name.
`PE1(config)#switchport`	config interface as switch port.
`PE2(config-if)#mpls-l2-circuit t3 service-template ST3`	Bind the interface to the VC with service template.
`PE2(config-if)#exit`	Exit interface mode.
`PE2(config)#mpls l2-circuit-fib-entry 300 2000 1000 1.1.1.1 xe1 xe2`	Configure the VC ID with the manual option (no signaling used).
`PE2(config)#end`	Exit configure mode.
`PE2(config)#commit`	Commit the transaction.

Validation

This example shows number of configured VCs and its status.

```
#show mpls vc-table count
 -------------------------------
  Num PWs       : 3
  Active PWs    : 3
  OAM-only PWs : 0
  Inactive PWs : 0
 -------------------------------

 #show ldp mpls-l2-circuit count
 ----------------------------------------------
 Num Signaled PWs: 3        [UP: 3]
 ----------------------------------------------
```

Service Template Configuration

PE-1

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit vc1 10 2.2.2.2`	Configure the VC
`(config-pseudowire)# service-tpid dot1.ad`	Configure Service-TPID as dot1.ad (0x88a8)
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)# service-template template1`	Configure the service template.
`(config-svc)# match double-tag outer-vlan 204 inner-vlan 203`	Matching criteria for service template.
`(config-svc)#rewrite ingress pop outgoing-tpid dot1.ad`	Action performed for service template.
`(config-svc)#exit`	Exit configure SVC mode
`(config)#interface xe2`	Specify the interface `(xe2)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#dot1ad ethertype 0x88a8`	Configure interface ethertype as dot1.ad (0x88a8)
`(config-if)#mpls-l2-circuit vc1 service-template template1`	Bind the interface to the VC with service template.
`(config-if)#commit`	Commit the transaction.
`(config-if)#end`	End of Interface and configurations mode.

PE-2

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit vc1 10 1.1.1.1`	Configure the VC.
`(config-pseudowire)#service-tpid dot1.ad`	Configure Service-TPID as dot1.ad (0x88a8)
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)# service-template template1`	Configure the service template.
`(config-svc)# match double-tag outer-vlan 204 inner-vlan 203`	Matching criteria for service template.
`(config-svc)# rewrite ingress pop outgoing-tpid dot1.ad`	Action performed for service template.
`(config-svc)#exit`	Exit configure SVC mode
`(config)#interface xe2`	Specify the interface `(xe2)` to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#dot1ad ethertype 0x88a8`	Configure interface ethertype as dot1.ad (0x88a8)
`(config-if)#mpls-l2-circuit vc1 service-template template1`	Bind the interface to the VC with service template.
`(config-if)#commit`	Commit the transaction.
`(config-if)#end`	End of interface and configurations mode.

Validation

PE1

```
PE1#show ldp mpls-l2-circuit detail
PW ID: 10, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 24322, remote label: 52482
Local MTU: 1500, Remote MTU: 1500
Local Control Word: disabled  Remote Control Word: Not-Applicable  Current
use: disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled



PE1#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: vc1, id: 10  PW-INDEX: 1 service-tpid: dot1.ad
 Endpoint: 2.2.2.2
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe2
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : template1
  Match criteria : 204/203
  Action type : Pop
  Outgoing tpid : dot1.ad


PE1#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label
Tunnel-Label  Nexthop        Status
10          N/A      N/A            xe2          xe1           52482
52480         2.2.2.2        Active
```

Service Template with Multiple Match

This is to validate the multiple match criteria support in a service template. When multiple match statements are configured only rewrite push is supported, rewrite translate and pop are not supported.

PE-1

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit t4 400 2.2.2.2`	Configure the VC for PE-1. In this example, t4 is the VC name, 400 is the VC ID, and 2.2.2.2 is the VC endpoint IP address.
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#service-template template4`	Template configuration
`(config-svc)# match outer-vlan 700`	Allow VLAN 700 traffic on this VC
`(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200`	Allow double tag match with s+c tags
`(config-svc)# match untagged`	Allow untagged traffic
`(config-svc)# rewrite ingress push 300`	Push Action performed for service template
`(config)#interface xe2`	Specify the interface (xe2) to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#mpls-l2-circuit t4 service-template template4`	Bind the interface to the VC with service template.
`(config-if)#commit`	Commit the transaction.

PE-2

`#configure terminal`	Enter configure mode.
`(config)#mpls l2-circuit t4 400 1.1.1.1`	Configure the VC for PE-2. In this example, t4 is the VC name, 400 is the VC ID, and 1.1.1.1 is the VC endpoint IP address.
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#service-template template4`	Template configuration
`(config-svc)# match outer-vlan 700`	Allow VLAN 700 traffic on this VC
`(config-svc)# match double-tag outer-vlan 1200 inner-vlan 3200`	Allow double tag match with s+c tags
`(config-svc)# match untagged`	Allow untagged traffic
`(config-svc)# rewrite ingress push 300`	Push Action performed for service template
`(config)#interface xe2`	Specify the interface (xe2) to be configured.
`(config-if)#switchport`	Switch to Layer-2 mode.
`(config-if)#mpls-l2-circuit t4 service-template template4`	Bind the interface to the VC with service template.
`(config-if)#commit`	Commit the transaction.

Validation

```
PE1#show ldp mpls-l2-circuit detail
PW ID: 400, VC state is up
Access IF: xe2,up,AC state is up
Session IF: xe1, state is up
Destination: 2.2.2.2, Peer LDP Ident: 2.2.2.2
Local vctype: vlan, remote vctype :vlan
Local groupid: 0, remote groupid: 0
Local label: 24324, remote label: 52485
Local MTU: 1500, Remote MTU: 1500
```

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```
Local Control Word: disabled  Remote Control Word: Not-Applicable  Current use: disabled
Local PW Status Capability : disabled
Remote PW Status Capability : disabled
Current PW Status TLV : disabled


PE1#show mpls l2-circuit detail
MPLS Layer-2 Virtual Circuit: t4, id: 400  PW-INDEX: 4 service-tpid: dot1.q

 Endpoint: 2.2.2.2
 Control Word: 0
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe2
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active
 Service-template : template4
  Match criteria : 700
 1200/3200
  untagged
  Action type : Push
  Action value : 300

PE1#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop         Status     Ecmp-Group
400          N/A      N/A            xe2           xe1           24322      24320         2.2.2.2         Active     N/A


PE2#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label  Nexthop         Status     Ecmp-Group
400          N/A      N/A            xe2           xe1           24321      24325         1.1.1.1         Active     N/A
```

VPWS-CFM

The below examples contains of Ethernet Operations and Management (OAM) configurations using the Connectivity Fault Management (CFM) protocol.

Connectivity Fault Management detects, verifies, isolates and notifies connectivity failures on a Virtual Bridged LAN (B-VLAN) based on the protocol standard specified in IEEE 802.1ag 2007. It provides discovery and verification of paths through 802.1 bridges and LANs and is part of the Operation, Administration and Management (OAM) module. CFM is transparent to customer data being transported by a network and is capable of providing maximum fault management.

Prerequisite

Configure basic VPWS configuration as in above section.

1. Configure the IP address and OSPF for the PE-1, P (Provider), and PE-2 routers.
2. Configure MPLS and LDP on PE-1, P, and PE-2, and LDP targeted peer for the PE-1 and PE-2 routers. (If RSVP is used for configuring trunks, LDP must be configured on PE-1 and PE-2, and RSVP must be configured on PE-1, P, and PE-2.)

PE1

`PE1#configure terminal`	Enter configure mode.
`PE1(config)#ethernet cfm domain-type character-string domain-name MD-05 level 0 mip-creation none`	Create cfm domain with type as character string and set mip creation criteria to default.

`PE1(config-ether-cfm)#service ma-type string ma-name CFM-2`	Create ma type as string and configure the ma
`PE1(config-ether-cfm-ma)# vpws vc1`	Configure vpws to associate to the MA
`PE1(config-ether-cfm-ma)# ethernet cfm mep up mpid 115 active true vpws vc1`	Create mep up on vpws.
`PE1(config-ether-cfm-ma-mep)#cc multicast state enable`	Enable cc multicast.
`PE1(config-ether-cfm-ma-mep)#exit-ether-ma-mep-mode`	Exit CFM MEP configuration mode.
`PE1(config-ether-cfm-ma)#mep crosscheck mpid 1115`	Configure crosscheck to remote MEP.
`PE1(config-ether-cfm-ma)#cc interval 10ms`	Enable cc interval for 10 millisecond.
`PE1(config-ether-cfm-ma)#exit-ether-ma-mode`	Exit CFM MA configuration mode.
`PE1(config-ether-cfm)#exit`	Exit ethernet CFM mode.
`PE1(config)#commit`	Commit the configuration
`PE1(config)#exit`	Exit the configure terminal mode

PE2

`PE2#configure terminal`	Enter configure mode.
`PE2(config)#ethernet cfm domain-type character-string domain-name MD-05 level 0 mip-creation none`	Create cfm domain with type as character string and set mip creation criteria to default.
`PE2(config-ether-cfm)#service ma-type string ma-name CFM-2`	Create ma type as string and set mip creation criteria to default.
`PE2(config-ether-cfm-ma)#vpws vc1`	Configure vpws to associate to the MA
`PE2(config-ether-cfm-ma)#ethernet cfm mep down mpid 1115 active true vpws vc1`	Create mep up on vpws.
`PE2(config-ether-cfm-ma-mep)#cc multicast state enable`	Enable cc multicast.
`PE2(config-ether-cfm-ma-mep)#exit-ether-ma-mep-mode`	Exit CFM MEP configuration mode
`PE2(config-ether-cfm-ma)#mep crosscheck mpid 115`	Configure crosscheck to remote MEP in VLAN 512.
`PE2(config-ether-cfm-ma)#cc interval 10ms`	Enable cc interval for 10 millisecond.
`PE2(config-ether-cfm-ma)#exit-ether-ma-mode`	Exit CFM MA configuration mode.
`PE2(config-ether-cfm)#exit`	Exit ethernet CFM mode.
`PE2(config)#commit`	Commit the configuration
`PE2(config)#exit`	Exit the configure terminal mode

Validation

PE1

```
PE1#show ethernet cfm statistics
Continuity Check Messages
```

```
   CCM Sent                : 4378
   CCM Received            : 0

Loop Back Messages
   LBM Sent                : 5
   LBR Received(Valid)     : 5
   LBR Received(Bad msdu)  : 0
   LBR Received(Out-of-Seq): 0

Link Trace Messages
   LTM Sent                : 2
   LTR Sent                : 0
   LTR Received(Valid)     : 2
   LTR Received(unexpected): 0

PE1#show ethernet cfm maintenance-points local mep domain MD-05 ma-name CFM-2
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address    Def Port  MD Name
---------------------------------------------------------------------------
115  Up  0   Enable  Installed  100 ms   b86a.97db.2eca F   xe4   MD-05

PE1#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 115       1115       0         Yes       False  f88e.a192.4436 Configured

PE1#show ethernet cfm ma status domain MD-05 ma-name CFM-2
MA NAME                  STATUS
-------------------------------
  CFM-2                  Active

PE1#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 115       1115       0         Yes       False  f88e.a192.4436 Configured

PE1#ping ethernet mac f88e.a192.4436 unicast source 115 domain MD-05 ma CFM-2
 success rate is  100 (5/5)

PE1#traceroute ethernet  f88e.a192.4436 mepid 115 domain MD-05 ma CFM-2
 MP Mac         Hops  Relay-action          Ingress/Egress  Ingress/Egress action
f88e.a192.4436   1     RlyHit                Ingress         IngOK
```

PE2

```
PE2#show ethernet cfm statistics
Continuity Check Messages
   CCM Sent                : 8841
   CCM Received            : 0

Loop Back Messages
```

```
   LBM Sent                : 5
   LBR Received(Valid)     : 5
   LBR Received(Bad msdu)  : 0
   LBR Received(Out-of-Seq): 0

Link Trace Messages
   LTM Sent                : 1
   LTR Sent                : 2
   LTR Received(Valid)     : 1
   LTR Received(unexpected): 0

PE2#show ethernet cfm maintenance-points local mep domain MD-05 ma-name CFM-2
MPID Dir Lvl CC-Stat HW-Status  CC-Intvl MAC-Address    Def Port  MD Name
---------------------------------------------------------------------------
1115 Up  0   Enable  Installed  100 ms   f88e.a192.4436 F   xe19  MD-05

PE2#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 1115      115        0         Yes       False  b86a.97db.2eca Configured

PE2#show ethernet cfm ma status domain MD-05 ma-name CFM-2
MA NAME                  STATUS
-------------------------------
  CFM-2                  Active
PE2#show ethernet cfm maintenance-points remote domain MD-05 ma-name CFM-2
 MEPID     RMEPID     LEVEL     Rx CCM    RDI    PEER-MAC        TYPE
----------------------------------------------------------------------
 1115      115        0         Yes       False  b86a.97db.2eca Configured

PE2#ping ethernet mac b86a.97db.2eca unicast source 1115 domain MD-05 ma CFM-2
 success rate is  100 (5/5)

PE2#traceroute ethernet b86a.97db.2eca mepid 1115 domain MD-05 ma CFM-2
 MP Mac         Hops  Relay-action          Ingress/Egress  Ingress/Egress action
b86a.97db.2eca   1     RlyHit                Ingress         IngOK
```

Layer 3 Virtual Private network Configuration

CHAPTER 1 L3VPN over EVPN MPLS Configuration

This chapter includes step-by-step configurations for L3VPN over EVPN MPLS.

Overview

L3vpn EVPN MPLS ensures that we are able to do the Ip-vrf to Ip-vrf routing with MPLS as overlay. We can ensure that with this model we can do the Anycast gateway using EVPN concepts. L3VPN EVPN MPLS is a way of integrating the interface-less model. In this model we will use non-irb interface i.e. L3 interface for the Ip-Vrf routing.

Using Anycast gateway idea is to have the Multi-Homed PE nodes to work in active-standby mode. From remote perspective at one time only one Peer PE will be active. If that PE goes down, then a new tunnel to the peer PE will be established for the traffic. From the access-side Traffic can reach to either of the peer PE and sent across the remote PE nodes. This way we can achieve redundancy using the anycast mac-address.

Topology

Below Topology depicts the topology for the L3VPN over EVPN MPLS configuration examples for both single homing and multi-homing with SR/LDP. MLAG configured between PE1 and PE2 to achieve multi-homing Active-Standby connected to CE1.

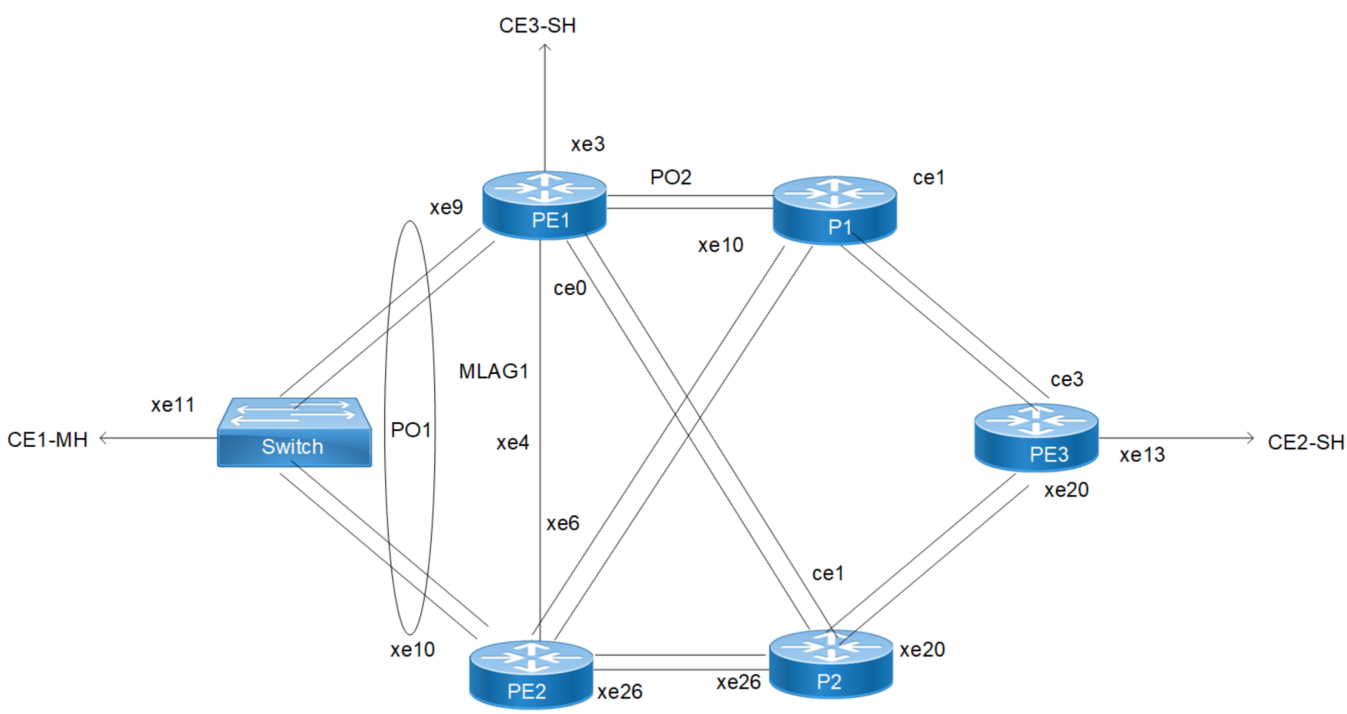

Figure 1-29: Topology diagram for L3VPN over EVPN MPLS

Configuration

PE1

Loopback Interface:

#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 1.1.1.1/32 secondary	Configure IP address on loopback interface.
(config-if)# prefix-sid index 1	Configuring prefix sid for segment id
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode

Global EVPN MPLS Command:

#configure terminal	Enter configuration mode.
(config)#load-balance enable	Enable Load balance
(config)#hardware-profile filter evpn-mpls-mh enable	Enable hardware profile for evpn mpls multihoming
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls irb	Enable EVPN MPLS IRB
(config)#evpn mpls multihoming enable	Enable EVPN MPLS multihoming
(config)#evpn mpls vtep-ip-global 1.1.1.1	Configuring VTEP global IP to loopback IP
(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4466	Confiiguring anycast gateway mac for MH. Note: Anycast gateway is mandatory for MH nodes.
(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.

Configure SR:

(config)#segment-routing	Configure segment routing
(config-sr)# mpls sr-prefer	Set mpls prefer segment routing over other protocols
(config-sr)#exit	Exit from router sr mode
(config)#commit	Commit the transaction.

Configure LDP:

(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 1.1.1.1	Configuring transport address
(config-router)#exit	Exit from router target peer and LDP mode
(config)#commit	Commit the transaction.

MLAG Configuration:

(config)#interface mlag1	Create mlag interface
(config-if)# switchport	Configuring as L2 port
(config-if)# load-interval 30	Configure load interval
(config-if)# exit	Exit from interface mode
(config)#interface po1	Configure dynamic lag
(config-if)# switchport	Configuring as L2 port
(config-if)# mtu 1500	Set mtu value
(config-if)# mlag 1	Attach mlag to po1. Note: While creating po1 subifp, this needs to be un-configured and configured back
(config-if)#interface xe10	Enter interface mode for xe10
(config-if)# channel-group 1 mode active	Attach lag interface po1
(config-if)#exit	Exit interface mode
(config)#mcec domain configuration	Create mcec domain
(config-mcec-domain)# domain-address 1111.2222.3333	Configure mcec domain address
(config-mcec-domain)# domain-system-number 1	Configure system number. Active node should have lower value.
(config-mcec-domain)# intra-domain-link xe4	Configure ideal interface between mlag devices
(config-mcec-domain)# domain-hello-timeout long	Configure domain hello timeout

Interface Configuration Network Side:

(config-if)#interface ce0	Configure network interface ce0
(config-if)# ip address 20.1.1.1/24	Configure IP address on the interface.
(config-if)# mtu 1522	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure mpls igp sync
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config)#interface po2	Create channel group po2
(config-if)# ip address 10.1.1.1/24	Configure IP address on the interface.
(config-if)# mtu 2000	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure mpls igp sync
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#interface xe18	Enter interface mode for xe18
(config-if)# channel-group 2 mode active	Attach lag interface po2
(config-if)#interface xe19	Enter interface mode for xe19

(config-if)# channel-group 2 mode active	Attach lag interface po2
(config)#commit	Commit the transaction.

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 23000	Configure SR global block for ospf
(config-router)# segment-routing mpls	Enable ospf SR
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

BGP Configuration:

(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 5.5.5.5 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Enter in to address family ipv4 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family l2vpn evpn	Enter in to address family l2vpn vpn
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 unicast	Enter in to address family ipv6 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf102	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf101	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp

(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf101	Enter in to address family ipv6 vrf vrf101
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf102	Enter in to address family ipv6 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family

IP VRF Configuration:

(config-vrf)#ip vrf vrf102	Enter VRF mode
(config-vrf)# rd 10001:102	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:102	Configure RT value
(config-vrf)# l3vni 102	Configure L3VNID to populate route through evpn
(config-vrf)#ip vrf vrf101	Enter VRF mode
(config-vrf)# rd 10001:1	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:1	Configure RT value
(config-vrf)# l3vni 101	Configure L3VNID to populate route through evpn

L3 VRF Port Configuration:

(config-if)#interface xe3	Enter the Interface mode for xe3. This is for untagged traffic
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 100.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1000::1/64	Assign ipv6 address
(config-if)#interface xe3.1	Create xe3.1 subifp
(config-if)# encapsulation dot1q 10	Configure encapsulation as single tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 110.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1100::1/64	Assign ipv6 address
(config-if)#interface xe3.2	Create xe3.2 subifp
(config-if)# encapsulation dot1q 11 inner-dot1q 11	Configure encapsulation as double tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 120.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1200::1/64	Assign ipv6 address
(config-if)#interface xe3.11	Create xe3.11 subifp
(config-if)# encapsulation dot1q 11	Configure encapsulation as single tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 111.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 1110::1/64	Assign ipv6 address

(config-if)#interface po1.11	Create po1 subinterface. We need to unconfigure mlag under po1 before creating subinterface.
(config-if)# encapsulation dot1q 11	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.11.1.1/24	Assign ipv4 address
(config-if)#interface po1.12	Create po1 subinterface.
(config-if)# encapsulation dot1q 12	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.12.1.1/24	Assign ipv4 address
(config-if)#interface po1.13	Create po1 subinterface.
(config-if)# encapsulation dot1q 13	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.13.1.1/24	Assign ipv4 address
(config-if)#interface po1.14	Create po1 subinterface.
(config-if)# encapsulation dot1q 14	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.14.1.1/24	Assign ipv4 address
(config-if)#interface po1.15	Create po1 subinterface.
(config-if)# encapsulation dot1q 15	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac
(config-if)# ip address 150.15.1.1/24	Assign ipv4 address
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
PE2 Configuration:	
Loopback Interface:	
#configure terminal	Enter configuration mode.
(config)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address on loopback interface.
(config-if)# prefix-sid index 2	Configuring prefix sid for segment id
(config-if)#commit	Commit the transaction.
(config-if)#exit	Exit interface mode

Global EVPN MPLS Command:

`#configure terminal`	Enter configuration mode.
`(config)#load-balance enable`	Enable Load balance
`(config)#hardware-profile filter evpn-mpls-mh enable`	Enable hardware profile for evpn mpls multihoming
`(config)#evpn mpls enable`	Enable EVPN MPLS
`(config)#evpn mpls irb`	Enable EVPN MPLS IRB
`(config)#evpn mpls multihoming enable`	Enable EVPN MPLS multihoming
`(config)#evpn mpls vtep-ip-global 2.2.2.2`	Configuring VTEP global IP to loopback IP
`(config)#evpn irb-forwarding anycast-gateway-mac 0011.2233.4466`	Configure Anycast gateway mac for MH. This command is mandatory for MH nodes.
`(config)#commit`	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature.

Configure SR:

`(config)#segment-routing`	Configure segment routing
`(config-sr)# mpls sr-prefer`	Set mpls prefer segment routing over other protocols
`(config-sr)#exit`	Exit from router sr mode
`(config)#commit`	Commit the transaction.

Configure LDP:

`(config)#router ldp`	Enter the Router LDP mode.
`(config-router)# transport-address ipv4 2.2.2.2`	Configuring transport address
`(config-router)#exit`	Exit from router target peer and LDP mode
`(config)#commit`	Commit the transaction.

MLAG Configuration:

`(config)#interface mlag1`	Create mlag interface
`(config-if)# switchport`	Configuring as L2 port
`(config-if)# load-interval 30`	Configure load interval
`(config-if)# exit`	Exit from interface mode
`(config)#interface po1`	Configure dynamic lag
`(config-if)# switchport`	Configuring as L2 port
`(config-if)# mtu 1500`	Set mtu value
`(config-if)# mlag 1`	Attach mlag
`(config-if)#interface xe9`	Enter interface mode
`(config-if)# speed 10g`	Set speed as 10g
`(config-if)# channel-group 1 mode active`	Attach the channel group po1

(config-if)# exit	Exit from interface mode
(config)#mcec domain configuration	Create mcec domain
(config-mcec-domain)# domain-address 1111.2222.3333	Configure mcec domain address
(config-mcec-domain)# domain-system-number 2	Configure system number
(config-mcec-domain)# intra-domain-link xe4	Configure ideal interface between mlag devices
(config-mcec-domain)# domain-hello-timeout long	Configure domain hello timeout
(config)#commit	Commit the transaction.

Interface Configuration Network Side:

(config-if)#interface xe6	Enter the Interface mode for xe6.
(config-if)# ip address 30.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#interface xe26	Enter the Interface mode for xe26.
(config-if)# ip address 40.1.1.1/24	Configure ipv4 address
(config-if)# mtu 2000	Configure mtu
(config-if)# label-switching	Enable label switching on the interface.
(config-if)# mpls ldp-igp sync ospf	Configure ldp sync with ospf
(config-if)# ip ospf network point-to-point	Configure ospf as p2p
(config-if)# enable-ldp ipv4	Enable LDP on the physical interface
(config-router)#exit	Exit interface mode
(config)#commit	Commit the transaction.

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# network 1.1.1.1/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# ospf segment-routing global block 16000 23000	Configure SR global block for ospf
(config-router)# segment-routing mpls	Enable ospf SR
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

BGP Configuration:

(config)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 5.5.5.5 remote-as 100	Configuring PE3 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 5.5.5.5 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 5.5.5.5 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Enter in to address family ipv4 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family l2vpn evpn	Enter in to address family l2vpn vpn
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 unicast	Enter in to address family ipv6 unicast mode
(config-router-af)# neighbor 5.5.5.5 activate	Activate PE3 neighbor
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf102	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf101	Enter in to address family ipv4 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf101	Enter in to address family ipv6 vrf vrf101
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf102	Enter in to address family ipv6 vrf vrf102
(config-router-af)# redistribute connected	Redistribute connected networks in to bgp
(config-router-af)# exit-address-family	Exit address family
(config)#commit	Commit the transaction.

IP VRF Configuration:

(config-vrf)#ip vrf vrf102	Enter VRF mode
(config-vrf)# rd 10001:102	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:102	Configure RT
(config-vrf)# l3vni 102	Configure L3VNI to send ipv4 route through evpn

(config-vrf)#ip vrf vrf101	Create ip vrf vrf101
(config-vrf)# rd 10001:1	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:1	Configure RT
(config-vrf)# l3vni 101	Configure L3VNI to send ipv4 route through evpn
(config)#commit	Commit the transaction.

L3 VRF Port Configuration:

(config-if)#interface po1.11	Create po1 subinterface. We need to unconfigure mlag under po1 before creating subinterface.
(config-if)# encapsulation dot1q 11	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)# ip address 150.11.1.1/24	Assign ipv4 address
(config-if)#interface po1.12	Create po1 subinterface.
(config-if)# encapsulation dot1q 12	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)# ip address 150.12.1.1/24	Assign ipv4 address
(config-if)#interface po1.13	Create po1 subinterface.
(config-if)# encapsulation dot1q 13	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)# ip address 150.13.1.1/24	Assign ipv4 address
(config-if)#interface po1.14	Create po1 subinterface.
(config-if)# encapsulation dot1q 14	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 150.14.1.1/24	Assign ipv4 address
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)#interface po1.15	Create po1 subinterface.
(config-if)# encapsulation dot1q 15	Configure encapsulation type and value
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 150.15.1.1/24	Assign ipv4 address
(config-if)# evpn irb-if-forwarding anycast-gateway-mac	Configure anycast gateway mac for multi-homing
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.

P1:

(config)#segment-routing	Configure SR.
(config-sr)# mpls sr-prefer	Prefer SR over other protocol.
(config-sr)#exit	Exit sr mode.
(config)#router ldp	Configure router ldp
(config-router)# transport-address ipv4 3.3.3.3	Configure transport address.
(config-router)#exit	Exit
(config)#interface po2	Configure dynamic LAG po2
(config-if)# ip address 10.1.1.2/24	Configure ipv4 address
(config-if)# mtu 2000	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface ce1	Configure network interface ce1
(config-if)# ip address 60.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface lo	Configure loopback interface
(config-if)# ip address 3.3.3.3/32 secondary	Configure secondary ip
(config-if)# prefix-sid absolute 16003	Configure SR segment id
(config-if)#interface xe10	Configure network interface xe10
(config-if)# speed 10g	Set speed 10g
(config-if)# ip address 30.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe14	Configure network interface xe14
(config-if)# ip address 50.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp

(config-if)#interface xe16	Enter interface mode
(config-if)# channel-group 2 mode active	Map dynamic lag po2
(config-if)#interface xe17	Enter interface mode
(config-if)# channel-group 2 mode active	Map dynamic lag po2
(config-if)# exit	Exit
(config)#router ospf 1	Configure router ospf 1
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Add loopback ip to ospf
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 30.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 50.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# segment-routing mpls	Enable SR ospf

P2:

(config)#segment-routing	Configure SR.
(config-sr)# mpls sr-prefer	Prefer SR over other protocol.
(config)#exit	Exit sr mode.
(config-sr)#router ldp	Configure router ldp
(config-router)# transport-address ipv4 4.4.4.4	Configure transport address.
(config-router)#exit	Exit
(config)#interface ce1	Configure network interface ce1
(config-if)# ip address 20.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface lo	Configure loopback interface
(config-if)# ip address 4.4.4.4/32 secondary	Configure secondary ip
(config-if)# prefix-sid absolute 16004	Configure SR segment id
(config-if)#interface xe14	Configure network interface xe14
(config-if)# ip address 50.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync

(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe20	Configure network interface xe20
(config-if)# ip address 70.1.1.1/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe26	Configure network interface xe26
(config-if)# ip address 40.1.1.2/24	Configure ipv4 address
(config-if)# mtu 2000	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#router ospf 1	Configure router ospf 1
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Add loopback ip to ospf
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 40.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 50.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# network 70.1.1.0/24 area 0.0.0.0	Add network address
(config-router)# segment-routing mpls	Enable SR ospf

PE3

Loopback Interface:	
#configure terminal	Enter configuration mode.
(config-if)#interface lo	Enter the Interface mode for the loopback interface.
(config-if)# ip address 5.5.5.5/32 secondary	Configure IP address on loopback interface.
(config-if)# prefix-sid absolute 16005	Configure SR segment id
(config)#commit	Commit the transaction.

Global EVPN MPLS Command:

(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls irb	Enable EVPN MPLS IRB

(config)#commit	Commit candidate configuration to be running configuration Note: Reload is required after Enabling/Disabling EVPN MPLS Feature
(config)#evpn mpls vtep-ip-global 5.5.5.5	Configuring VTEP global IP to loopback IP
(config-evpn-mpls)#commit	Commit the transaction.

IP VRF Configuration:

(config-vrf)#ip vrf vrf102	Enter VRF mode
(config-vrf)# rd 10001:102	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:102	Configure RT value
(config-vrf)# l3vni 102	Configure L3VNI to send ipv4 route through evpn
(config-vrf)#ip vrf vrf101	Create ip vrf vrf101
(config-vrf)# rd 10002:1	Configuring Route-Distinguisher value
(config-vrf)# route-target both 1.1.1.1:1	Configure RT value
(config-vrf)# l3vni 101	Configure L3VNI to send ipv4 route through evpn
(config)#commit	Commit the transaction.

Cofigure SR:

(config)#segment-routing	Configure SR
(config-sr)# mpls sr-prefer	Prefer SR over other protocols for mpls
(config)#commit	Commit the transaction.
Global LDP:	
(config)#router ldp	Enter the Router LDP mode.
(config-router)# transport-address ipv4 5.5.5.5	Configure transport address
(config-router)#exit	Exit
(config)#commit	Commit the transaction.

Interface Configuration Network Side:

(config-if)#interface ce3	Configure network interface ce3
(config-if)# ip address 60.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching
(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config-if)#interface xe20	Enter the Interface mode for xe20.
(config-if)# ip address 70.1.1.2/24	Configure ipv4 address
(config-if)# mtu 1522	Configure MTU
(config-if)# label-switching	Configure label switching

(config-if)# mpls ldp-igp sync ospf	Configure ldp ospf sync
(config-if)# ip ospf network point-to-point	Configure ospf p2p
(config-if)# enable-ldp ipv4	Enable ldp
(config)#commit	Commit the transaction.

OSPF Configuration:

(config)#router ospf 1	Enter the Router OSPF mode.
(config-router)# network 5.5.5.5/32 area 0.0.0.0	Advertise loopback address in OSPF.
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# network 70.1.1.0/24 area 0.0.0.0	Advertise network address in OSPF.
(config-router)# segment-routing mpls	Enable SR ospf
(config-router)#exit	Exit Router OSPF mode and return to Configure mode.
(config)#commit	Commit the transaction.

BGP Configuration:

(config-router)#router bgp 100	Enter the Router BGP mode, ASN: 100
(config-router)# neighbor 1.1.1.1 remote-as 100	Configuring PE1 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 1.1.1.1 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 2.2.2.2 remote-as 100	Configuring PE2 as iBGP neighbor using it's loopback IP
(config-router)# neighbor 2.2.2.2 fall-over bfd multihop	Configure BFD
(config-router)# neighbor 1.1.1.1 update-source lo	Source of routing updates as loopback
(config-router)# neighbor 2.2.2.2 update-source lo	Source of routing updates as loopback
(config-router)# address-family ipv4 unicast	Enter ipv4 unicast address family
(config-router-af)# neighbor 1.1.1.1 activate	Activate neighbor PE1
(config-router-af)# neighbor 2.2.2.2 activate	Activate neighbor PE2
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family l2vpn evpn	Enter evpn address family
(config-router-af)# neighbor 1.1.1.1 activate	Activate neighbor PE1
(config-router-af)# neighbor 2.2.2.2 activate	Activate neighbor PE2
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 unicast	Enter ipv6 unicast address family
(config-router-af)# neighbor 1.1.1.1 activate	Activate neighbor PE1

(config-router-af)# neighbor 2.2.2.2 activate	Activate neighbor PE2
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf102	Enter vrf vrf102 address family
(config-router-af)# redistribute connected	Redisdribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf102	Enter ipv6 vrf vrf102 address family
(config-router-af)# redistribute connected	Redisdribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv4 vrf vrf101	Enter vrf vrf102 address family
(config-router-af)# redistribute connected	Redisdribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)# address-family ipv6 vrf vrf101	Enter ipv6 vrf vrf101 address family
(config-router-af)# redistribute connected	Redisdribute vrf connected routes to bgp
(config-router-af)# exit-address-family	Exit address family
(config-router)#exit	Exit bgp mode
(config)#commit	Commit the transaction.

L3 VRF Port Configuration:

(config-if)#interface xe13	Enter the Interface mode for xe3. This is for untagged traffic
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 201.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 2001::1/64	Assign ipv6 address
(config-if)#interface xe13.1	Create subinterface xe13.1
(config-if)# encapsulation dot1q 10	Configure encapsulation single tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 210.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 2100::1/64	Assign ipv6 address
(config-if)#interface xe13.2	Create subinterface xe13.2
(config-if)# encapsulation dot1q 11 inner-dot1q 11	Configure encapsulation double tagged
(config-if)# ip vrf forwarding vrf101	Map the vrf vrf101
(config-if)# ip address 220.1.1.1/24	Assign ipv4 address
(config-if)# ipv6 address 2200::1/64	Assign ipv6 address
(config)#commit	Commit the transaction.

Validation

PE1

```
7030-PE1#sh mlag domain summary
------------------------------------
Domain Configuration
------------------------------------

Domain System Number            : 1
Domain Address                  : 1111.2222.3333
Domain Priority                 : 32768
Intra Domain Interface          : xe4
Domain Adjacency                : UP
Domain Sync via                 : Intra-domain-interface
------------------------------------
MLAG Configuration
------------------------------------

MLAG-1
  Mapped Aggregator             : po1
  Physical properties Digest    : a2 58 27 76 9f 45 ff 6c 2a 62 65 aa b6 22 8f 81
  Total Bandwidth               : 0
  Mlag Sync                     : IN_SYNC
  Mode                          : Active-Standby
  Current Mlag state            : Active
  Switchover-mode               : Revertive

7030-PE1#
Note:
PE1#sh etherchannel summary
  Aggregator po1 100001
  Aggregator Type: Layer2
  Admin Key: 16385 - Oper Key 16385
     Link: xe10 (5011) sync: 1 (Mlag-Active-link)
--------------------------------------
  Aggregator po2 100002
  Aggregator Type: Layer3
  Admin Key: 0002 - Oper Key 0002
     Link: xe18 (10025) sync: 1
     Link: xe19 (10026) sync: 1
PE1#sh evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
==================================================================================
1.1.1.1          5.5.5.5          Installed     02:22:38      02:22:38      102

Total number of entries are 1
PE1#sh ip bgp vrf all
BGP table version is 1, local router ID is 120.1.1.1
```

```
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path

BGP Route Table for VRF vrf101
*>i  45.1.1.0/24      5.5.5.5              0        100       0    ?
*>i  52.1.1.0/24      5.5.5.5              0        100       0    ?
*>   100.1.1.0/24     0.0.0.0              0        100       32768  ?
*>i  101.101.101.2/32 5.5.5.5              0        100       0    ?
*>   101.101.101.101/32
                      0.0.0.0              0        100       32768  ?
*>   110.1.1.0/24     0.0.0.0              0        100       32768  ?
*>   111.1.1.0/24     0.0.0.0              0        100       32768  ?
*                     0.0.0.0              1        100       32768  ?
*>   120.1.1.0/24     0.0.0.0              0        100       32768  ?
*>i  201.1.1.0        5.5.5.5              0        100       0    ?
*>i  210.1.1.0        5.5.5.5              0        100       0    ?
*>i  220.1.1.0        5.5.5.5              0        100       0    ?

Total number of prefixes 11

BGP Route Table for VRF vrf102
*>i  45.1.1.0/24      5.5.5.5              0        100       0    ?
*>   51.1.1.0/24      0.0.0.0              0        100       32768  ?
*>i  52.1.1.0/24      5.5.5.5              0        100       0    ?
*>i  101.101.101.2/32 5.5.5.5              0        100       0    ?
*>i  201.1.1.0        5.5.5.5              0        100       0    ?
*>i  210.1.1.0        5.5.5.5              0        100       0    ?
*>i  220.1.1.0        5.5.5.5              0        100       0    ?

Total number of prefixes 7
*>i  5.5.5.5/32       5.5.5.5              0        100       0    i

Total number of prefixes 1
PE1#sh bgp l2vpn evpn prefix-route

RD[10002:1]
ESI  Eth-Tag Prefix-Length   IP-Address  GW-IPAddress   L3VNID/LABEL   Nexthop  Encap
Router-Mac
0    0       24            201.1.1.0   0.0.0.0       17             5.5.5.5  MPLS
0000:0000:0000
0    0       24            210.1.1.0   0.0.0.0       17             5.5.5.5  MPLS
0000:0000:0000
0    0       24            220.1.1.0   0.0.0.0       17             5.5.5.5  MPLS
0000:0000:0000
0    0       64             2001::     ::            17             5.5.5.5  MPLS
0000:0000:0000
0    0       64             2100::     ::            17             5.5.5.5  MPLS
0000:0000:0000
```

```
0    0      64              2200::     ::            17             5.5.5.5  MPLS
0000:0000:0000
PE1#sh mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

LDP ilm-ecmp - disabled
Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                 pri    LSP-Type
   O>   5.5.5.5/32        7          16005       16005       N/A        po2
10.1.1.2                Yes    LSP_DEFAULT
   O>   3.3.3.3/32        5          16003       3           N/A        po2
10.1.1.2                Yes    LSP_DEFAULT
   B>   vrf101           2          17         Nolabel     N/A       vrf101          N/
A                     Yes    LSP_DEFAULT
   B>   vrf102           1          16         Nolabel     N/A       vrf102          N/
A                     Yes    LSP_DEFAULT
   O>   4.4.4.4/32        6          16004       3           N/A        ce0
20.1.1.2                Yes    LSP_DEFAULT
   L>   4.4.4.4/32        10         35202       3           N/A        ce0
20.1.1.2                Yes    LSP_DEFAULT
   L>   3.3.3.3/32        8          35200       3           N/A        po2
10.1.1.2                Yes    LSP_DEFAULT
   L>   60.1.1.0/24       9          35201       3           N/A        po2
10.1.1.2                Yes    LSP_DEFAULT
   O>   20.1.1.2/32       3          35840       3           N/A        ce0
20.1.1.2                Yes    LSP_DEFAULT
   L>   70.1.1.0/24       12         35204       3           N/A        ce0
20.1.1.2                Yes    LSP_DEFAULT
   O>   10.1.1.2/32       4          35841       3           N/A        po2
10.1.1.2                Yes    LSP_DEFAULT
PE1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   O>   3.3.3.3/32         1         5         0           Yes   LSP_DEFAULT  3
po2         No    10.1.1.2
   L    3.3.3.3/32         9         4         -           Yes   LSP_DEFAULT  3
po2         No    10.1.1.2
   O>   4.4.4.4/32         2         6         0           Yes   LSP_DEFAULT  3
ce0         No    20.1.1.2
   L    4.4.4.4/32         4         3         -           Yes   LSP_DEFAULT  3
ce0         No    20.1.1.2
   O>   5.5.5.5/32         3         8         0           Yes   LSP_DEFAULT  16005
po2         No    10.1.1.2
```

```
   L    5.5.5.5/32          5        13        -          Yes   LSP_DEFAULT  34567
po2          No    10.1.1.2
                                    14        -          Yes   LSP_DEFAULT  34566
ce0          No    20.1.1.2
   L>   50.1.1.0/24         7          15(e)
                                    4         -          Yes   LSP_DEFAULT  3
po2          No    10.1.1.2
                                    3         -          Yes   LSP_DEFAULT  3
ce0          No    20.1.1.2
   L>   60.1.1.0/24         10         16
                                    4         -          Yes   LSP_DEFAULT  3
po2          No    10.1.1.2
   L>   70.1.1.0/24         8          10
                                    3         -          Yes   LSP_DEFAULT  3
ce0          No    20.1.1.2
PE1#
```

PE2

```
PE2#show mlag domain summary

------------------------------------
Domain Configuration
------------------------------------

Domain System Number            : 2
Domain Address                  : 1111.2222.3333
Domain Priority                 : 32768
Intra Domain Interface          : xe4
Domain Adjacency                : UP
Domain Sync via                 : Intra-domain-interface
------------------------------------
MLAG Configuration
------------------------------------

MLAG-1
  Mapped Aggregator             : po1
  Physical properties Digest    : a2 58 27 76 9f 45 ff 6c 2a 62 65 aa b6 22 8f 81
  Total Bandwidth               : 0
  Mlag Sync                     : IN_SYNC
  Mode                          : Active-Standby
  Current Mlag state            : Standby
  Switchover-mode               : Revertive


PE2#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
==================================================================================
2.2.2.2          5.5.5.5          Installed     1d02h23m      1d02h23m      101
```

```
Total number of entries are 1

PE2#show evpn mpls tunnel label
EVPN-MPLS Network tunnel labels
 (*) in Policy - tunnel-policy inherited from mac-vrf
================+===========+=========+===============+=========+=========+=========+==
=======+============+========+============+========
                                                            Local           Remote
MPLS-Multipath          Underlay
 Destination     Status      VPN-ID    Policy          MC-Label  UC-Label  MC-Label  UC-
Label  Grp-Name     NHLFE-ix  NW-Intf      NW-Label
================+===========+=========+===============+=========+=========+=========+==
=======+============+========+============+========
 5.5.5.5        Installed   101      --             --       17       --        --
--         --         --        --

Total number of entries are 1
PE2#show bgp l2vpn evpn prefix-route

RD[10002:1]
ESI   Eth-Tag Prefix-Length    IP-Address      GW-IPAddress   L3VNID/LABEL    Nexthop
Encap     Router-Mac
0     0       24               45.1.1.0        0.0.0.0        17              5.5.5.5
MPLS      0000:0000:0000
0     0       24               52.1.1.0        0.0.0.0        17              5.5.5.5
MPLS      0000:0000:0000
0     0       24               201.1.1.0       0.0.0.0        17              5.5.5.5
MPLS      0000:0000:0000
0     0       24               210.1.1.0       0.0.0.0        17              5.5.5.5
MPLS      0000:0000:0000
0     0       24               220.1.1.0       0.0.0.0        17              5.5.5.5
MPLS      0000:0000:0000
0     0       32               101.101.101.2   0.0.0.0        17              5.5.5.5
MPLS      0000:0000:0000
0     0       64               2001::          ::             17              5.5.5.5
MPLS      0000:0000:0000
0     0       64               2100::          ::             17              5.5.5.5
MPLS      0000:0000:0000
0     0       64               2200::          ::             17              5.5.5.5
MPLS      0000:0000:0000
PE2#show ip bgp vrf all
BGP table version is 1, local router ID is 0.0.0.0
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf   Weight Path

BGP Route Table for VRF vrf101
*>i  201.1.1.0        5.5.5.5             0         100        0    ?
*>i  210.1.1.0        5.5.5.5             0         100        0    ?
*>i  220.1.1.0        5.5.5.5             0         100        0    ?
```

```
Total number of prefixes 6
*>i  5.5.5.5/32       5.5.5.5              0        100       0    i

Total number of prefixes 1
PE2#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

LDP ilm-ecmp - disabled
Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                  pri    LSP-Type
   O>   5.5.5.5/32         8           16005       16005       N/A        xe6
30.1.1.2                 Yes    LSP_DEFAULT
   O>   1.1.1.1/32         5           16001       16001       N/A        xe6
30.1.1.2                 Yes    LSP_DEFAULT
   B>   vrf101           2           17          Nolabel    N/A       vrf101          N/
A                      Yes    LSP_DEFAULT
   B>   vrf102           1           16          Nolabel    N/A       vrf102          N/
A                      Yes    LSP_DEFAULT
   O>   4.4.4.4/32         7           16004       3           N/A        xe26
40.1.1.2                 Yes    LSP_DEFAULT
   O>   3.3.3.3/32         6           16003       3           N/A        xe6
30.1.1.2                 Yes    LSP_DEFAULT
   L>   10.1.1.0/24        13          35204       3           N/A        xe6
30.1.1.2                 Yes    LSP_DEFAULT
   L>   20.1.1.0/24        10          35201       3          N/A        xe26
40.1.1.2                 Yes    LSP_DEFAULT
   L>   4.4.4.4/32         9           35200       3          N/A        xe26
40.1.1.2                 Yes    LSP_DEFAULT
   L>   3.3.3.3/32         12          35203       3          N/A        xe6
30.1.1.2                 Yes    LSP_DEFAULT
   L>   70.1.1.0/24        11          35202       3          N/A        xe26
40.1.1.2                 Yes    LSP_DEFAULT
   O>   30.1.1.2/32        3           35840       3          N/A        xe6
30.1.1.2                 Yes    LSP_DEFAULT
   L>   60.1.1.0/24        14          35205       3          N/A        xe6
30.1.1.2                 Yes    LSP_DEFAULT
   O>   40.1.1.2/32        4           35841       3          N/A        xe26
40.1.1.2                 Yes    LSP_DEFAULT
PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf     ELC   Nexthop
   O>   1.1.1.1/32         1         6         0           Yes   LSP_DEFAULT  16001
xe6          No    30.1.1.2
```

```
   L    1.1.1.1/32         5        16        -          Yes   LSP_DEFAULT  34573
xe26        No    40.1.1.2
                                   17        -          Yes   LSP_DEFAULT  34573
xe6         No    30.1.1.2
   O>   3.3.3.3/32         2        7         0          Yes   LSP_DEFAULT  3
xe6         No    30.1.1.2
   L    3.3.3.3/32         6        3         -          Yes   LSP_DEFAULT  3
xe6         No    30.1.1.2
   O>   4.4.4.4/32         3        8         0          Yes   LSP_DEFAULT  3
xe26        No    40.1.1.2
   L    4.4.4.4/32         11       4         -          Yes   LSP_DEFAULT  3
xe26        No    40.1.1.2
   O>   5.5.5.5/32         4        10        0          Yes   LSP_DEFAULT  16005
xe6         No    30.1.1.2
   L    5.5.5.5/32         7        19        -          Yes   LSP_DEFAULT  34575
xe26        No    40.1.1.2
                                   20        -          Yes   LSP_DEFAULT  34575
xe6         No    30.1.1.2
   L>   10.1.1.0/24         8        14
                                   3         -          Yes   LSP_DEFAULT  3
xe6         No    30.1.1.2
   L>   20.1.1.0/24         12       21
                                   4         -          Yes   LSP_DEFAULT  3
xe26        No    40.1.1.2
   L>   50.1.1.0/24         9        22(e)
                                   4         -          Yes   LSP_DEFAULT  3
xe26        No    40.1.1.2
                                   3         -          Yes   LSP_DEFAULT  3
xe6         No    30.1.1.2
   L>   60.1.1.0/24         10       14
                                   3         -          Yes   LSP_DEFAULT  3
xe6         No    30.1.1.2
   L>   70.1.1.0/24         13       21
                                   4         -          Yes   LSP_DEFAULT  3
xe26        No    40.1.1.2
PE2#

PE3:

PE3#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source           Destination      Status        Up/Down       Update        evpn-id
=======================================================================================
5.5.5.5          1.1.1.1          Installed     2d05h17m      2d05h17m      102
5.5.5.5          1.1.1.1          Installed     2d05h17m      2d05h17m      101

Total number of entries are 2
PE3#show ip bgp vrf all
BGP table version is 1, local router ID is 220.1.1.1
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal,
              l - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
    Network          Next Hop            Metric    LocPrf   Weight Path

BGP Route Table for VRF vrf101
*>   45.1.1.0/24      210.1.1.2            0        100       32768  ?
*>i  51.1.1.0/24      1.1.1.1              0        100       0    ?
*>   52.1.1.0/24      0.0.0.0              0        100       32768  ?
*>i  100.1.1.0/24     1.1.1.1              0        100       0    ?
*>   101.101.101.2/32 0.0.0.0              0        100       32768  ?
*>i  101.101.101.101/32
                      1.1.1.1              0        100       0    ?
*>i  110.1.1.0/24     1.1.1.1              0        100       0    ?
*>i  111.1.1.0/24     1.1.1.1              0        100       0    ?
*>i  120.1.1.0/24     1.1.1.1              0        100       0    ?
*>   201.1.1.0        0.0.0.0              0        100       32768  ?
*>   210.1.1.0        0.0.0.0              0        100       32768  ?
*>   220.1.1.0        0.0.0.0              0        100       32768  ?

Total number of prefixes 12

...skipping 1 line
BGP Route Table for VRF vrf102
*>i  51.1.1.0/24      1.1.1.1              0        100       0    ?

Total number of prefixes 1
*>   5.5.5.5/32       0.0.0.0              0        100       32768  i

Total number of prefixes 1

PE3#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

LDP ilm-ecmp - disabled
Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop      pri    LSP-Type
   O>   4.4.4.4/32        6          16004       3           N/A        xe20
70.1.1.1     Yes    LSP_DEFAULT
   B>   vrf101            2         17          Nolabel     N/A        vrf101          N/
A          Yes    LSP_DEFAULT
   B>   vrf102            1         16          Nolabel     N/A        vrf102          N/
A          Yes    LSP_DEFAULT
   O>   3.3.3.3/32        5          16003       3           N/A        ce3
60.1.1.1     Yes    LSP_DEFAULT
   O>   1.1.1.1/32        12         16001       16001       N/A        ce3
60.1.1.1     Yes    LSP_DEFAULT
   L>   20.1.1.0/24       10         35203       3           N/A        xe20
70.1.1.1     Yes    LSP_DEFAULT
```

```
   L>   4.4.4.4/32         8           35201       3           N/A        xe20
70.1.1.1     Yes    LSP_DEFAULT
   L>   3.3.3.3/32         7           35200       3           N/A        ce3
60.1.1.1     Yes    LSP_DEFAULT
   L>   40.1.1.0/24        9           35202       3           N/A        xe20
70.1.1.1     Yes    LSP_DEFAULT
   O>   70.1.1.1/32        4           35840       3           N/A        xe20
70.1.1.1     Yes    LSP_DEFAULT
   L>   10.1.1.0/24        11          35204       3           N/A        ce3
60.1.1.1     Yes    LSP_DEFAULT
   O>   60.1.1.1/32        3           35841       3           N/A        ce3
60.1.1.1     Yes    LSP_DEFAULT
PE3#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   O>   1.1.1.1/32         9         13        0           Yes   LSP_DEFAULT  16001
ce3         No    60.1.1.1
   L    1.1.1.1/32         10        14        -           Yes   LSP_DEFAULT  34566
ce3         No    60.1.1.1
                                    16        -           Yes   LSP_DEFAULT  34564
xe20        No    70.1.1.1
   O>   3.3.3.3/32         1         6         0           Yes   LSP_DEFAULT  3
ce3         No    60.1.1.1
   L    3.3.3.3/32         3         3         -           Yes   LSP_DEFAULT  3
ce3         No    60.1.1.1
   O>   4.4.4.4/32         2         7         0           Yes   LSP_DEFAULT  3
xe20        No    70.1.1.1
   L    4.4.4.4/32         5         4         -           Yes   LSP_DEFAULT  3
xe20        No    70.1.1.1
   L>   10.1.1.0/24        8           8
                                    3         -           Yes   LSP_DEFAULT  3
ce3         No    60.1.1.1
   L>   20.1.1.0/24        7           10
                                    4         -           Yes   LSP_DEFAULT  3
xe20        No    70.1.1.1
   L>   40.1.1.0/24        6           10
                                    4         -           Yes   LSP_DEFAULT  3
xe20        No    70.1.1.1
   L>   50.1.1.0/24        4           11(e)
                                    4         -           Yes   LSP_DEFAULT  3
xe20        No    70.1.1.1
                                    3         -           Yes   LSP_DEFAULT  3
ce3         No    60.1.1.1
```

PE3

```
PE3#show bgp l2vpn evpn prefix-route

RD[10001:1]
```

```
ESI                 Eth-Tag Prefix-Length   IP-Address      GW-IPAddress  L3VNID/LABEL
Nexthop   Encap       Router-Mac
0                    0       24              100.1.1.0       0.0.0.0       17
1.1.1.1   MPLS        0000:0000:0000
0                    0       24              110.1.1.0       0.0.0.0       17
1.1.1.1   MPLS        0000:0000:0000
0                    0       24              111.1.1.0       0.0.0.0       17
1.1.1.1   MPLS        0000:0000:0000
0                    0       24              120.1.1.0       0.0.0.0       17
1.1.1.1   MPLS        0000:0000:0000
0                    0       64              1000::          ::            17
1.1.1.1   MPLS        0000:0000:0000
0                    0       64              1100::          ::            17
1.1.1.1   MPLS        0000:0000:0000
0                    0       64              1110::          ::            17
1.1.1.1   MPLS        0000:0000:0000
0                    0       64              1200::          ::            17
1.1.1.1   MPLS        0000:0000:0000

RD[10001:102]
ESI                 Eth-Tag Prefix-Length   IP-Address      GW-IPAddress  L3VNID/LABEL
Nexthop   Encap       Router-Mac
0                    0       24              51.1.1.0        0.0.0.0       16
1.1.1.1   MPLS        0000:0000:0000
PE3#
```

CHAPTER 2 L3VPN GR Configuration

Using BGP graceful restart, the data-forwarding plane of a router can continue to process and forward packets even if the control plane - which is responsible for determining best paths - fails. Graceful restart also reduces routing flaps, stabilizing the network and reducing control-plane resource consumption.

By exchanging a new BGP capability (BGP capability code 64) in the initial BGP open messages that establish the session, the restarting router and its peers show that they are aware of the BGP graceful restart mechanism when the initial BGP connection is established. In addition, the restarting router provides its peers with a list of supported address-families (VPNv4, IPv4, and IPV6) for which it can maintain a forwarding state across a BGP restart.

The peer router's TCP connection might be cleared, when the router's BGP process is restarted. Under normal circumstances, this would cause the peer router to clear all routes associated with the restarting router. But with a BGP graceful restart, this doesn't happen. Instead, in expectation of the restarting router shortly re-establishing the BGP session, the peer router marks all routes as “stale” yet continues to use them to forward packets. Likewise, the restarting router also continues forwarding packets in the interim.

When the restarting router opens the new BGP session, it will again send BGP capability 64 to its peers. But this time, flags will be set in the graceful restart capabilities exchange to let the peer router know that the BGP process has restarted.

The goal of the BGP graceful restart was to minimize the duration and reach of an outage associated with a failed BGP process. To do this, the software extensions must be deployed on both the router restarting the BGP process and the BGP peers of that router. The peers help the BGP process regain lost forwarding information and also help isolate failures from the rest of the network.

While forwarding packets, the peer router will refresh the restarting router with any relevant BGP routing information base (RIB) updates. The peer signals that it has finished sending the updates with an "End-of-RIB" (EOR) marker - an “empty” BGP update message. EOR markers help speed convergence because once the restarting router has received them from all peers, it can begin best-path selection again using the new routing information. Similarly, the restarting router then sends any updates to its peer routers and uses the EOR marker to indicate the completion of the process.

As part of this feature, we will be extending the feature for VPNv4 AF.

Topology

In the below example shows to configure BGP VPNv4 neighborship between PE1 and PE2.

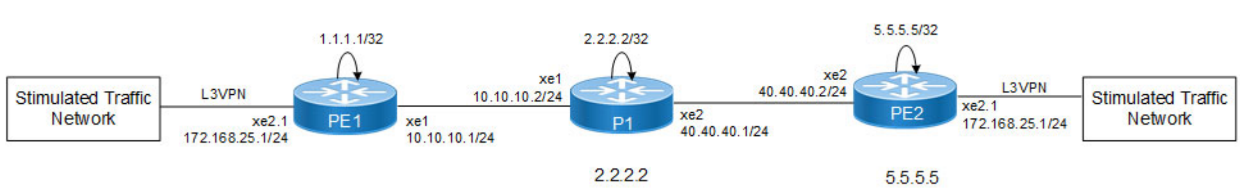

Figure 2-30: L3VPN GR Topology

L3VPN GR Configuration

Configuration

Below are the configurations and validations of L3VPN GR with OSPF as IGP. We can also configure ISIS as IGP and LDP/RSVP as transport.

PE1

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to 1.1.1.1/32
`(config-if)#exit`	Exit interface mode.
`(config)#ip-vrf l3vpn`	Configure IP VRF L3VPN.
`(config-vrf)#rd 1:300`	Enter RD value.
`(config-vrf)#route-target both 300:400`	Enter RT value.
`(config-vrf)#exit`	Exiting from VRF mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1.
`(config-router)#targeted-peer ipv4 2.2.2.2`	Configure targeted peer.
`(config-router-targeted-peer)#exit-targeted- peer-mode`	Exit-targeted-peer-mode
`(config-router)#targeted-peer ipv4 5.5.5.5`	Configure targeted peer.
`(config-router-targeted-peer)#exit-targeted- peer-mode`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.10.1/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2.1`	Configure access-port .
`(config-if)#description MPLS-L3VPN`	Giving Interface Description
`(config-if)#encapsulation dot1q 4`	Setting Encapsulation to dot1q with VLAN ID 4
`(config-if)#load-interval 30`	Load interval setting
`(config-if)#ip vrf forwarding l3vpn`	Bind the interface connected to the CE router with VRF l3vpn
`(config-if)#ip address 172.168.25.2/24`	Assign the IPv4 address.
`(config)#router ospf 1`	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config)#ospf router-id 1.1.1.1`	Configure OSPF router-ID same as loopback interface IP address

(config-router) #network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router) #network 10.10.10.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Enter router BGP mode
(config-router)#bgp router-id 1.1.1.1	Configuring the BGP router id 1.1.1.1.
(config-router)#bgp graceful-restart restart-time 100	Enable BGP GR with restart timer 100.
(config-router)#neighbor 5.5.5.5 remote-as 100	Configure neighbor 5.5.5.5.
(config-router)#neighbor 5.5.5.5 update-source lo	Update source lo for neighbor 5.5.5.5.
(config-router)#address-family ipv4 unicast	Enter address-family IPv4 unicast.
(config-router-af)#redistribute connected	Redistribute connected.
(config-router)#neighbor 5.5.5.5 activate	Activate neighbor.
(config-router)#address-family vpnv4 unicast	Entering Address family VPNv4 unicast.
(config-router-af)#neighbor 5.5.5.5 activate	Activate the neighbor 5.5.5.5.
(config-router-af)#neighbor 5.5.5.5 capability graceful-restart	Activate capability graceful restart for neighbor 5.5.5.5.
(config-router-af)#exit-address-family	Exit address family.
(config-router)#address-family ipv4 vrf l3vpn	Entering address family.
(config-router-af)#redistribute connected	Redistribute connected.
(config-router)#neighbor 172.168.25.1 remote-as 600	Configure neighbor 172.168.25.1.
(config-router)#neighbor 172.168.25.1 activate	Activate neighbor.
(config-router-af)#commit	Commit all the transactions.

P1

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router)#transport-address ipv4 2.2.2.2 0	Configure the transport address for IPV4 (for IPV6, use ipv6) to be used for a TCP session over which LDP will run.
Note:	It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted- peer-mode	Exit-targeted-peer-mode.
(config-router)#targeted-peer ipv4 5.5.5.5	Configure targeted peer.

`(config-router-targeted-peer)#exit-targeted- peer-mode`	Exit-targeted-peer-mode.
`(config-router)#exit`	Exit-targeted-peer-mode.
`(config-if)#exit`	Exit router mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.10.2/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 40.40.40.1/24`	Configure IPv4 address for xe2.
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Configure the routing process and specify the Process ID. The Process ID should be a unique positive integer identifying the routing process.
`(config)#ospf router-id 2.2.2.2`	Configure OSPF router-ID same as loopback interface IP address.
`(config-router) #network 2.2.2.2/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router) #network 10.10.10.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 40.40.40.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#bfd all-interfaces`	Enable the OSPF enabled interfaces with BFD.
`(config-if)#exit`	Exit interface mode.

PE-2

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 5.5.5.5/32 secondary`	Set the IP address of the loopback interface to 5.5.5.5/32.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 5.5.5.5`	Set the router ID to IP address 5.5.5.5.
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted peer.
`(config-router-targeted-peer)#exit-targeted- peer-mode`	Exit-targeted-peer-mode.
`(config-router)#targeted-peer ipv4 2.2.2.2`	Configure targeted peer.
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit-targeted-peer-mode.
`(config-router)#exit`	Exit router mode.
`(config)#interface xe1`	Enter interface mode.

`(config-if)#ip address 40.40.40.2/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#exit`	Exit interface mode.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2.1`	Enter interface mode.
`(config-if)#description MPLS-L3VPN`	Giving Interface Description.
`(config-if)#encapsulation dot1q 4`	Setting Encapsulation to dot1q with VLAN ID 4.
`(config-if)#load-interval 30`	Load interval setting.
`(config-if)#ip vrf forwarding l3vpn`	Bind the interface connected to the CE router with VRF L3VPN.
`(config-if)#ip address 172.168.25.2/24`	Assign the IPv4 address.
`(config)#router ospf 1`	The Process ID should be a unique positive integer identifying the routing process.
`(config)#ospf router-id 5.5.5.5`	Configure OSPF router-ID same as loopback interface IP address.
`(config-router) #network 5.5.5.5/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router) #network 40.40.40.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 100`	Enter router BGP mode
`(config-router)#bgp router-id 5.5.5.5`	Configuring the bgp router id 1.1.1.1.
`(config-router)#bgp graceful-restart restart-time 100`	Enable BGP GR with restart timer 100.
`(config-router)#neighbor 1.1.1.1 remote-as 100`	Configure neighbor 1.1.1.1.
`(config-router)#neighbor 1.1.1.1 update-source lo`	Update source lo for neighbor 1.1.1.1.
`(config-router)#address-family ipv4 unicast`	Enter address-family ipv4 unicast.
`(config-router-af)#redistribute connected`	Redistribute connected.
`(config-router)#neighbor 1.1.1.1 activate`	Activate neighbor.
`(config-router)#address-family vpnv4 unicast`	Entering Address family VPNv4 unicast.
`(config-router-af)#neighbor 1.1.1.1 activate`	Activate the neighbor 1.1.1.1.
`(config-router-af)#neighbor 1.1.1.1 capability graceful-restart`	Activate capability graceful restart for neighbor 1.1.1.1.
`(config-router-af)#exit-address-family`	Exit address family.
`(config-router)#address-family ipv4 vrf l3vpn`	Entering address family.
`(config-router-af)#redistribute connected`	Redistribute connected.
`(config-router)#neighbor 172.168.26.1 remote-as 700`	Configure neighbor 172.168.26.1.
`(config-router)#neighbor 172.168.26.1 activate`	Activate neighbor.
`(config-router-af)#commit`	Commit all the transactions.

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Validation

Restart BGP Gracefully

PE1:

```
PE1#restart bgp graceful
%Warning : BGP process will stop and needs to restart manually,
You may lose bgp configuration,if not saved
Proceed for graceful restart? (y/n):y
%% Managed module is down or crashed

R1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
      K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                    LSP-Type
                          LSP_DEFAULT
   B> p 77.77.80.0/24      7           24323       Nolabel     N/A        l3vpn
N/A                        LSP_DEFAULT
   B> p 77.77.78.0/24      5           24321       Nolabel     N/A        l3vpn
N/A                        LSP_DEFAULT
   B> p 77.77.77.0/24      4           24320       Nolabel     N/A        l3vpn
N/A                        LSP_DEFAULT
   B> p 77.77.79.0/24      6           24322       Nolabel     N/A        l3vpn
N/A                        LSP_DEFAULT
   B> p 77.77.81.0/24      8           24324       Nolabel     N/A        l3vpn
N/A                        LSP_DEFAULT
   B> p 172.168.25.0/24    9           24325       Nolabel     N/A        l3vpn
N/A                        LSP_DEFAULT

   V    l2ckt:900         1           24960       Nolabel     po1        xe1             N/
A                        LSP_DEFAULT

PE1#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport

Code     FEC                  FTN-ID    Tunnel-id   Pri   LSP-Type     Out-Label    Out-
Intf     Nexthop

  B> p 88.88.88.0/24      1        0          Yes   LSP_DEFAULT  24321       -
5.5.5.5
  B>p 88.88.89.0/24      2        0          Yes   LSP_DEFAULT  24321       -
5.5.5.5
   B> p 88.88.90.0/24      3        0          Yes   LSP_DEFAULT  24321       -
5.5.5.5
```

```
   B >p 88.88.91.0/24      4        0          Yes   LSP_DEFAULT  24321       -
5.5.5.5
   B >p 88.88.92.0/24      5        0          Yes   LSP_DEFAULT  24321       -
5.5.5.5
   B> p 172.168.26.0/24    6        0          Yes   LSP_DEFAULT  24321       -
5.5.5.5

PE1#show nsm forwarding-timer
Protocol-Name  GR-State  Time Remaining (sec)   Disconnected-time
     BGP        ACTIVE           74          2022/01/13 16:33:43

PE#show run bgp
!
PE1#show ip bgp vpnv4 all
```

PE2:

```
PE2#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:300 (Default for VRF l3vpn)
*>i  77.77.77.0/24    1.1.1.1              0        100       0   600 i
*>i  77.77.78.0/24    1.1.1.1              0        100       0   600 i
*>i  77.77.79.0/24    1.1.1.1              0        100       0   600 i
*>i  77.77.80.0/24    1.1.1.1              0        100       0   600 i
*>i  77.77.81.0/24    1.1.1.1              0        100       0   600 i
*> l 88.88.88.0/24    172.168.26.1         0        100       0   700 i
*> l 88.88.89.0/24    172.168.26.1         0        100       0   700 i
*> l 88.88.90.0/24    172.168.26.1         0        100       0   700 i
*> l 88.88.91.0/24    172.168.26.1         0        100       0   700 i
*> l 88.88.92.0/24    172.168.26.1         0        100       0   700 i
*>i  172.168.25.0/24  1.1.1.1              0        100       0    ?
*> l 172.168.26.0/24  0.0.0.0              0        100       32768  ?
 Announced routes count = 6
 Accepted routes count = 6
Route Distinguisher: 1:300
S>i  77.77.77.0/24    1.1.1.1              0        100       0   600 i
S>i  77.77.78.0/24    1.1.1.1              0        100       0   600 i
S>i  77.77.79.0/24    1.1.1.1              0        100       0   600 i
S>i  77.77.80.0/24    1.1.1.1              0        100       0   600 i
S>i  77.77.81.0/24    1.1.1.1              0        100       0   600 i
S>i  172.168.25.0/24  1.1.1.1              0        100       0    ?
 Announced routes count = 0
```

After Restarting the BGP Manually

PE1:

```
PE1#start-shell
bash-5.0$ su
Password:
root@PE1:/home/ocnos# cd /usr/local/sbin/
root@PE1:/usr/local/sbin# ./bgpd -d

PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
      K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                    LSP-Type
   B> 77.77.80.0/24      7          24323       Nolabel     N/A        l3vpn           N/
A                        LSP_DEFAULT
   B> 77.77.78.0/24      5          24321       Nolabel     N/A        l3vpn           N/
A                        LSP_DEFAULT
   B> 77.77.77.0/24      4          24320       Nolabel     N/A        l3vpn           N/
A                        LSP_DEFAULT
   B> 77.77.79.0/24      6          24322       Nolabel     N/A        l3vpn           N/
A                        LSP_DEFAULT
   B> 77.77.81.0/24      8          24324       Nolabel     N/A        l3vpn           N/
A                        LSP_DEFAULT
   B> 172.168.25.0/24    9          24325       Nolabel     N/A        l3vpn           N/
A                        LSP_DEFAULT
   V    l2ckt:900         1          24960       Nolabel     po1        xe1             N/
A                        LSP_DEFAULT

PE1#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport

Code    FEC                  FTN-ID    Tunnel-id   Pri   LSP-Type     Out-Label    Out-
Intf     Nexthop

  B>88.88.88.0/24       1         0           Yes   LSP_DEFAULT  24321        -
5.5.5.5
  B>88.88.89.0/24       2         0           Yes   LSP_DEFAULT  24321        -
5.5.5.5
   B>88.88.90.0/24       3         0           Yes   LSP_DEFAULT  24321        -
5.5.5.5
   B>88.88.91.0/24       4         0           Yes   LSP_DEFAULT  24321        -
5.5.5.5
   B>88.88.92.0/24       5         0           Yes   LSP_DEFAULT  24321        -
5.5.5.5
   B> 172.168.26.0/24     6         0           Yes   LSP_DEFAULT  24321        -
5.5.5.5
```

PE2:

```
PE2#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

    Network          Next Hop            Metric    LocPrf      Weight Path
Route Distinguisher: 1:300 (Default for VRF l3vpn)
*>i 77.77.77.0/24    1.1.1.1              0         100       0   600 i
*>i 77.77.78.0/24    1.1.1.1              0         100       0   600 i
*>i 77.77.79.0/24    1.1.1.1              0         100       0   600 i
*>i 77.77.80.0/24    1.1.1.1              0         100       0   600 i
*>i 77.77.81.0/24    1.1.1.1              0         100       0   600 i
*> l 88.88.88.0/24    172.168.26.1         0         100       0   700 i
*> l 88.88.89.0/24    172.168.26.1         0         100       0   700 i
*> l 88.88.90.0/24    172.168.26.1         0         100       0   700 i
*> l 88.88.91.0/24    172.168.26.1         0         100       0   700 i
*> l 88.88.92.0/24    172.168.26.1         0         100       0   700 i
*>i 172.168.25.0/24 1.1.1.1              0         100       0  ?
*> l 172.168.26.0/24 0.0.0.0              0         100       32768 ?
 Announced routes count = 6
 Accepted routes count = 6
Route Distinguisher: 1:300
>i 77.77.77.0/24    1.1.1.1              0         100       0   600 i
>i 77.77.78.0/24    1.1.1.1              0         100       0   600 i
>i 77.77.79.0/24    1.1.1.1              0         100       0   600 i
>i 77.77.80.0/24    1.1.1.1              0         100       0   600 i
>i 77.77.81.0/24    1.1.1.1              0         100       0   600 i
>i 172.168.25.0/24 1.1.1.1              0         100       0    ?
 Announced routes count = 0
```

CHAPTER 3 TWAMP over L3VPN Configuration

This chapter contains a complete sample TWAMP over L3VPN configuration.

Two-way Active Measurement Protocol (TWAMP) is an open protocol for measuring network performance between any two devices. The TWAMP MPLS transport is implemented as part of supporting TWAMP on routers which acts as MPLS routers both in the roles of LERs as well as intermediate routers. OcNOS version 6.0.0 also supports the end to end statistics calculation when multiple paths are available between sender and reflector with multihop support.

The user can use the link delay metrics such as average, minimum, and maximum delay, and delay variance to determine the network latency. Using link delay metrics will enable troubleshooting latency issues or apply Traffic Engineering (TE) solutions to meet Service Level Agreements (SLAs).

The TWAMP protocol is designed to do such measurements, and a basic implementation of this protocol has already been implemented in OcNOS. This feature here is a TWAMP protocol in OcNOS where the focus will be on accuracy and configurable advertisement of the measured data.

L3VPN (based on MPLS) Supported scenarios:

In general, TWAMP over L3VPN works on:

CE-CE Overlay Only

CE-PE Overlay Only

PE-PE Both Under lay and over lay

Topology

Figure 3-31 displays a sample TWAMP over L3VPN topology.

- CE1 and CE2 are customer edge routers
- PE1 and PE2 are IPv4 Provider Edge routers
- P1 is the router at the core of the IPv4 MPLS provider network

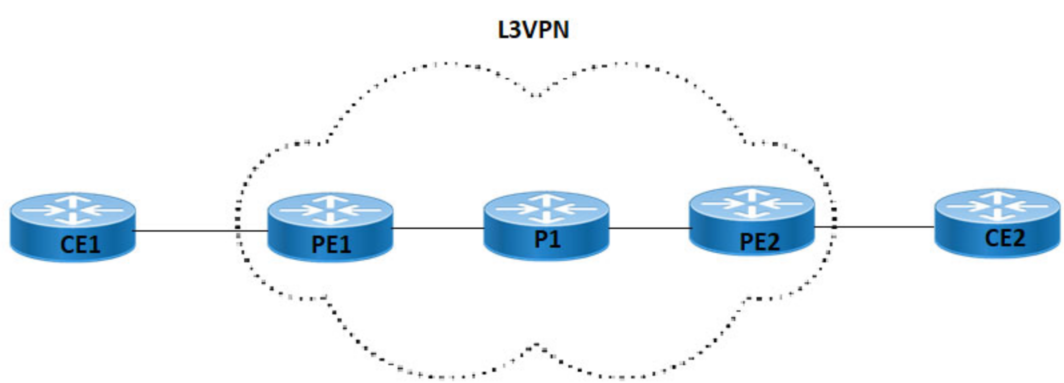

Figure 3-31: TWAMP over L3VPN Topology

Configure TWAMP over L3VPN for LDP

PE1

`#configure terminal`	Enter Configure mode.
`(config)# ip vrf vrf100`	Create a new VRF named vrf100
`(config-vrf)#rd 100:1`	Assign the route distinguisher (RD) value as 100:1
`(config-vrf)#route-target both 100:1`	Import routes between route target (RT) ext-communities 100 and 1
`(config-vrf)#exit`	Exit VRF mode
`(config)#interface lo`	Enter loopback interface mode
`(config-if)#ip address 18.18.18.18/32 sec-ondary`	Assign IP address to Loopback interface
`(config-if)#exit`	Exit Interface mode
`(config)#interface xe8`	Enter Interface mode
`(config-if)# ip address 10.1.1.18/24`	Assign IP address to interface
`(config-if)#enable-ldp ipv4`	Enable LDP on the physical interface
`(config-if)#label-switching`	Enable label switching on the interface
`(config-if)#exit`	Exit Interface mode
`(config)#interface xe11`	Enter Interface mode
`(config-if)# ip vrf forwarding vrf100`	Bind the interface connected to the CE1 router with VRF 100
`(config-if)# ip address 100.1.1.1/24`	Assign IP address to interface
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter the Router LDP mode
`(config-router)#router-id 18.18.18.18`	Configure router id as loopback address
`(config-router)#transport-address ipv4 18.18.18.18`	Configure ldp transport addess as loopback address
`(config-router)#exit`	Exit from the router ldp mode
`(config)# router ospf 1`	Enter Router OSPF mode
`(config-router)# ospf router-id 18.18.18.18`	Configure OSPF router-id
`(config-router)# network 10.1.1.0/24 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`(config-router)# network 18.18.18.18/32 area 0.0.0.0`	Define the network on which OSPF runs and associate area id.
`(config-router)# commit`	Commit the configurations
`(config-router)# exit`	Exit from router OSPF mode
`(config)# router bgp 100`	Enter BGP router mode
`(config-router)# bgp router-id 18.18.18.18`	Configure BGP router-id
`(config-router)# neighbor 8.8.8.8 remote-as 100`	Configure PE2 as an iBGP4+ neighbor
`(config-router)# neighbor 8.8.8.8 up-date-source lo`	Update the source as loopback for iBGP peering with the remote PE2 router

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(config-router)# address-family vpnv4 unicast	Enter address-family vpnv4 mode
(config-router-af)# neighbor 8.8.8.8 activate	Activate the PE2 neighbor in the vpnv4 address family
(config-router-af)# neighbor 8.8.8.8 next-hop-self	Activate the neighbor as next hop self
(config-router-af)#exit	Exit form address family
(config-router)# address-family ipv4 vrf vrf100	Enter the IPv4 address family for VRF 100
(config-router-af)# redistribute connected	Redistribute connected routes
(config-router-af)# neighbor 100.1.1.2 remote-as 200	Configure CE1 neighbor in the vrf address family
(config-router-af)# neighbor 100.1.1.2 activate	Activate the CE1 neighbor
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

P1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 3.3.3.3/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 3.3.3.3	Configure router id as loopback address
(config-router)#transport-address ipv4 3.3.3.3	Configure ldp transport addess as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface xe14	Enter Interface mode
(config-if)# ip address 10.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe15	Enter Interface mode
(config-if)# ip address 11.1.1.3/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 18.18.18.18	Configure OSPF router-id
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.

(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# commit	Commit the configurations
(config-router)# exit	Exit from router OSPF mode

PE2

#configure terminal	Enter Configure mode.
(config)#ip vrf vrf100	Create a new VRF named vrf100
(config-vrf)#rd 101:1	Assign the route distinguisher (RD) value as 101:1
(config-vrf)#route-target both 100:1	Import routes between route target (RT) ext-communities 100 and 1
(config-vrf)#exit	Exit VRF mode
(config)#router ldp	Enter the Router LDP mode
(config-router)#router-id 8.8.8.8	Configure router id as loopback address
(config-router)#transport-address ipv4 8.8.8.8	Configure ldp transport addess as loopback address
(config-router)#exit	Exit from the router ldp mode
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 8.8.8.8/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe24	Enter Interface mode
(config-if)# ip address 11.1.1.8/24	Assign IP address to interface
(config-if)#enable-ldp ipv4	Enable LDP on the physical interface
(config-if)#label-switching	Enable label switching on the interface
(config-if)#exit	Exit Interface mode
(config)#interface xe25	Enter Interface mode
(config-if)# ip vrf forwarding vrf100	Bind the interface connected to the CE1 router with VRF 100
(config-if)# ip address 101.1.1.1/24	Assign IP address to interface
(config-if)#exit	Exit interface mode
(config)# router ospf 1	Enter Router OSPF mode
(config-router)# ospf router-id 8.8.8.8	Configure OSPF router-id
(config-router)# network 11.1.1.0/24 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)# network 8.8.8.8/32 area 0.0.0.0	Define the network on which OSPF runs and associate area id.
(config-router)#exit	Exit from router OSPF mode
(config)# router bgp 100	Enter BGP router mode
(config-router)# bgp router-id 8.8.8.8	Configure BGP router-id
(config-router)# neighbor 18.18.18.18 remote-as 100	Configure PE1 as an iBGP4+ neighbor
(config-router)# neighbor 18.18.18.18 update-source lo	Update the source as loopback for iBGP peering with the remote PE1 router

(config-router)# address-family vpnv4 unicast	Enter address-family vpnv4 mode
(config-router-af)# neighbor 18.18.18.18 activate	Activate the PE1 neighbor in the vpnv4 address family
(config-router-af)# neighbor 18.18.18.18 next-hop-self	Activate the neighbor as next hop self
(config-router-af)#exit	Exit form address family
(config-router)# address-family ipv4 vrf vrf100	Enter the IPv4 address family for VRF 100
(config-router-af)# redistribute connected	Redistribute connected routes
(config-router-af)# neighbor 101.1.1.2 remote-as 200	Configure CE2 neighbor in the vrf address family
(config-router-af)# neighbor 101.1.1.2 activate	Activate the CE2 neighbor
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

CE1

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter loopback interface mode
(config-if)#ip address 37.37.37.37/32 secondary	Assign IP address to Loopback interface
(config-if)#exit	Exit Interface mode
(config)#interface xe24	Enter Interface mode
(config-if)# ip address 100.1.1.2/24	Assign IP address to interface
(config-if)#exit	Exit Interface mode
(config)#interface xe26	Enter Interface mode
(config-if)# ip address 200.1.1.1/24	Assign IP address to interface
(config-if)#exit	Exit interface mode
(config)# router bgp 200	Enter BGP router mode
(config-router)# bgp router-id 37.37.37.37	Configure BGP router-id
(config-router)#neighbor 100.1.1.1 remote-as 100	Configure PE1 as an eBGP4+ neighbor
(config-router)# address-family ipv4 unicast	Enter address-family IPv4 unicast mode
(config-router-af)# redistribute connected	Redistribute the connected route under address family IPv4 unicast
(config-router-af)# neighbor 100.1.1.1 activate	Activate the neighbor in the IPv4 address family
(config-router-af)#exit	Exit form address family
(config-router)# commit	Commit the configurations

CE2

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter loopback interface mode
`(config-if)#ip address 2.2.2.2/32 secondary`	Assign IP address to Loopback interface
`(config-if)#exit`	Exit Interface mode
`(config)#interface xe14`	Enter Interface mode
`(config-if)# ip address 101.1.1.2/24`	Assign IP address to interface
`(config-if)#exit`	Exit Interface mode
`(config)#interface xe15`	Enter Interface mode
`(config-if)# ip address 201.1.1.1/24`	Assign IP address to interface
`(config-if)#exit`	Exit interface mode
`(config)# router bgp 300`	Enter BGP router mode
`(config-router)# bgp router-id 2.2.2.2`	Configure BGP router-id
`(config-router)#neighbor 101.1.1.1 remote-as 100`	Configure PE2 as an eBGP4+ neighbor
`(config-router)# address-family ipv4 unicast`	Enter address-family IPv4 unicast mode
`(config-router-af)# redistribute connected`	Redistribute the connected route under address family IPv4 unicast
`(config-router-af)# neighbor 101.1.1.1 activate`	Activate the neighbor in the IPv4 address family
`(config-router-af)#exit`	Exit form address family
`(config-router)# commit`	Commit the configurations

TWAMP Configuration on Sender (PE1)

TWAMP sender is configured to measure the delay on interface Loopback on PE1

`#configure terminal`	Enter Configure mode.
`(config)# hardware-profile filter twamp-ipv4 enable`	Enable hardware filter for ipv4 to configure TWAMP measurement configs
`(config)#commit`	Commit the configuration
`(config)# twamp-light control`	Enable TWAMP light controller on PE1
`(config-twamp-light-con)# control-admin-state enable`	Enable TWAMP Controller admin state
`(config)#interface lo`	Enter Interface Loopback mode
`(config-if)# delay-measurement dynamic twamp reflector-ip 11.1.1.8`	Configure delay measurement on interface Loopback to reflector PE2
`(config-if)#commit`	Commit the configurations
`(config-if)#end`	Return to privilege mode

TWAMP Configuration on Reflector (PE2)

Configure TWAMP Reflector as interface xe24 on PE2 (Towards core)

`#configure terminal`	Enter Configure mode.
`(config)# hardware-profile filter twamp-ipv4 enable`	Enable hardware filter for ipv4 to configure TWAMP measurement configs
`(config)#commit`	Commit the configuration
`(config)# twamp-light reflector`	Enable TWAMP light Reflector on PE2
`(config-twamp-light-ref)# reflec-tor-admin-state enable`	Enable the TWAMP reflector admin state
`(config-twamp-light-ref)# reflector-name pe2 reflector-ip ipv4 11.1.1.8`	Configure TWAMP reflector IP as PE2 interface IP
`(config-twamp-light-ref)#commit`	Commit the configurations
`(config-if)#end`	Return to privilege mode

Validation

1. Verify ping from PE1 to PE2

```
PE1#ping 11.1.1.8
Press CTRL+C to exit
PING 11.1.1.8 (11.1.1.8) 56(84) bytes of data.
64 bytes from 11.1.1.8: icmp_seq=1 ttl=63 time=0.683 ms
64 bytes from 11.1.1.8: icmp_seq=2 ttl=63 time=0.491 ms
64 bytes from 11.1.1.8: icmp_seq=3 ttl=63 time=0.594 ms
```

2. Verify mpls l3vpn ping from PE1

```
PE1#ping mpls l3vpn vrf100 101.1.1.0/24
Sending 5 MPLS Echos to 101.1.1.0, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

  !
  !
  !
  !
  !

     Success Rate is 100.00 percent (5/5)
```

3. Verify the TWAMP statistics on all the configured interfaces on PE1

In the below verification command, packets sent and received showing as equal. So all the TWAMP packets received reply for all the sent packets for the delay measurement. Showing all the Round Trip Delay and Reverse Delay timers.

```
PE1#sh twamp-statistics
=========================================
      TWAMP Test-Session Statistics
=========================================
  Test-Session Name        : __internal_interface_xe8
  Start Time               : 2019 Feb 14 15:21:58
  Elapsed time(milli sec)  : 6003
  Packets Sent             : 6
  Packets Received         : 6
  Packet Loss(%)           : 0.00
  Round Trip Delay(usec)
      Minimum              : 17
      Maximum              : 19
      Average              : 18
  Forward Delay(usec)
      Minimum              : (*)
      Maximum              : (*)
      Average              : (*)
  Reverse Delay(usec)
      Minimum              : (*)
      Maximum              : (*)
      Average              : (*)
  Round Trip Delay Variation(usec)
      Minimum              : 16
      Maximum              : 19
      Average              : 17
  Forward Delay Variation(usec)
      Minimum              : (*)
      Maximum              : (*)
      Average              : (*)
  Reverse Delay Variation(usec)
      Minimum              : (*)
      Maximum              : (*)
      Average              : (*)

(*) - Time is not in sync between Sender and Reflector
```

4. Verify the List of all interfaces that are currently participating in Delay measurement

```
PE1#sh twamp-statistics interfaces
Interface Last Advertisement Delay(us)  Min(us)  Max(us)  Var(us)       Loss(%)
   Xe8    2019-02-14 15:22:00      10       10       10         0   Not Enabled
```

5. Verify the Detailed list of TWAMP delay measurement information on interface xe8

```
PE1#sh twamp-statistics interfaces xe8
Interface name    : xe8
Sender IP         : 10.1.1.18
Reflector IP      : 11.1.1.8
Reflector port    : 862
DSCP value        : 0
HW Status         : HW rules installed
Last Advertised stats:
  Time: 2019-02-14 15:22:00
  Average delay          : 10
  Minimum delay          : 10
  Maximum delay          : 10
  Average delay variation: 0
  Minimum delay variation: 0
  Maximum delay variation: 0
  Packets sent           : 1
  Packets received       : 1
  Packets timeout        : 0
  Packet Loss: Not Enabled
Last Calculated stats:
  Time: 2019-02-14 15:22:00
  Average delay          : 10
  Minimum delay          : 10
  Maximum delay          : 10
  Average delay variation: 0
  Minimum delay variation: 0
  Maximum delay variation: 0
  Packets sent           : 1
  Packets received       : 1
  Packets timeout        : 0
Packet Loss : Not Enabled
```

CHAPTER 4 DHCP Relay Agent Over L3VPN Configuration

Refer to DHCP Relay Agent Over L3VPN Configuration section in *System Management Configuration* guide.

CHAPTER 5 DSCP Preserve

Overview

Layer 3 VPN services use the DSCP field in the IP header to convey QoS information, determining packet priority and treatment (e.g., DSCP 46 for high-priority voice traffic). When L3 VPN traffic enters the MPLS domain, QoS is managed by the EXP field in the MPLS label, typically derived from the DSCP value. In Qumran-based systems, the EXP field is updated based on the remarked DSCP value. By default, remarking the DSCP at the access interface affects both the IP header DSCP field and the MPLS EXP field. Service managers need control over whether to remark the DSCP or not while configuring EXP field updates.

Network operator can control preserving DSCP in the edge routers at gobal level or per VRF level or combination of both. To provide more control, the following DSCP preservation settings are available:

- DSCP Preserve Global - When DSCP preserve is enabled globally, it applies to all VRFs, preserving the DSCP value even if remarking is configured.
- DSCP Preserve Per-VRF - Per-VRF configuration allows DSCP preservation only for specific VPN services, offering more granular control for network administrators.

DSCP Preserve Behavior: Below table shows the way DSCP preserve global and per VRF configuration impact the DSCP value of the traffic received on the VRF of interest when dscp-to-queue profile is updated with remark DSCP option.

Table 5-15:

DSCP-preserve	per-vrf not configured	per-vrf enabled	per-vrf disabled
Global enable	preserved	preserved	not preserved
Global disable	not preserved	preserved	not preserved

Network administrators can further refine control using global or custom DSCP-to-queue profiles and policy-map configurations to remark DSCP values based on specific match criteria. This provides flexible and tailored QoS management across different VPN services.

DSCP Preserve Characteristics

- QoS information mapping ensures that the QoS information carried in the DSCP field of the IP header is correctly mapped to the MPLS EXP field.
- DSCP remarking controls whether the DSCP value in the IP header is remarked at the access interface, affecting both customer traffic and the MPLS domain.
- In hardware like Qumran, the EXP field update is based on the remarked DSCP value, requiring configuration to manage how and if DSCP values are modified.
- Ingress configuration requirement introduces the need for ingress-side configuration to properly align the DSCP and EXP field values, ensuring correct QoS handling.
- DSCP preserve provides service managers with control over whether DSCP values are modified or preserved during the process of mapping to MPLS headers.

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DSCP Preserve Global

This method of configuration allows Network operator to enable or disable DSCP preserve for all the services in an edge router.

Prerequisites

The L3VPN service will operate seamlessly from end to end without any packet loss, using either OSPF or IS-IS as the IGP, with traffic profiles configured based on user-defined DSCP values.

- Globally enable dscp-preserve using the `mpls lsp-encap-dscp-preserve` command.
- Global level configuration for PE1:

```
config t
qos enable
!
qos profile dscp-to-queue profile1
dscp 24 queue 3 dscp 32
```

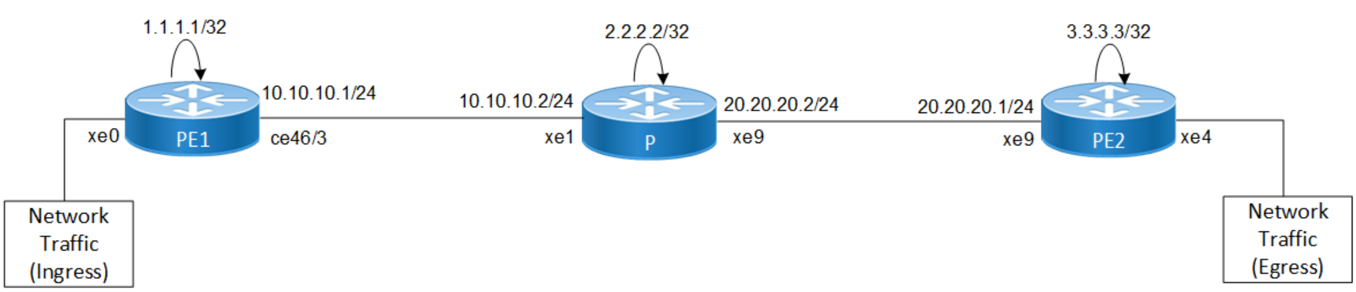
- interface level configuration for PE1:

```
interface xe3
qos map-profile dscp-to-queue profile1
!
```

Configuration for DSCP Preserve Global

Topology

The topology above illustrates the DSCP Preserve Global feature, with PE1 and PE2 serving as the edge routers for L3VPN services, and the P node acting as a transit router between them. Traffic received on PE1 with a user-defined DSCP value, which can be preserved or modified depending on the configuration applied to the ingress PE router.



DSCP Preserve Global

Configure DSCP Preserve and L3VPN Services on PE1 Router

1. Enable QoS Globally: This command enables global QoS functionality, allowing configuration of any QoS-related settings. It is mandatory to enable this feature for any QoS configurations to be effective.

```
PE1(config)#qos enable
PE1(config)#commit
```

2. Configure DSCP Preserve Globally: This command enables preserving the customer's DSCP values across the network.

```
PE1(config)#mpls lsp-encap-dscp-preserve
```

3. Configure QoS profiles or class-map profiles for remarking the incoming customer defined DSCP value to customized DSCP value.
   - Method 1: QoS Profile (dscp-to-queue): Use a QoS profile to remap the incoming DSCP value to a user-defined queue and DSCP value.

```
PE1(config)#qos profile dscp-to-queue dscp_profile1
PE1(config-ingress-dscp-map)#dscp 24 queue 3 dscp 32
PE1(config-ingress-dscp-map)#commit
PE1(config-ingress-dscp-map)#exit
PE1(config)#Interface xe0.100
PE1(config-if)#qos map-profile dscp-to-queue dscp_profile1
PE1(config-if)#commit
PE1(config-if)#exit
```

   - Method 2: Class-Map and Policy-Map: Use class-map and policy-map to match the incoming DSCP value and set a new DSCP value.

```
PE1(config)#class-map type qos match-any class1
PE1(config-qos-match-any)#match dscp 24
PE1(config-qos-match-any)#commit
PE1(config-qos-match-any)#exit

PE1(config)#policy-map type qos pmap1
PE1(config-pmap-qos)#class type qos class1
PE1(config-pmap-qos)#set dscp 32
PE1(config-pmap-qos)#commit
PE1(config-pmap-qos)#exit

PE1(config)#Interface xe0.100
PE1(config-if)#service-policy type qos input pmap1
PE1(config-if)#commit
```

4. Configure EXP Encapsulation on the Egress Interface: Modify the incoming EXP value to a user-defined EXP value for MPLS traffic.
   - Example config on Qumran 1:

```
PE1(config)#qos profile exp-encap exp_profile1
PE1(config-egress-exp-encap-map)#l3 dscp 32 exp 5
PE1(config-egress-exp-encap-map)#commit
PE1(config-egress-exp-encap-map)#exit
PE1(config)#interface ce46/3
PE1(config-if)#label-switching
PE1(config-if)#qos map-profile exp-encap exp_profile1
PE1(config-if)#commit
PE1(config-if)#exit
```

   - Example config on Qumran 2:

```
PE1(config)#qos profile queue-to-exp exp_profile1
PE1(config-egress-queue-exp-map)#queue 3 color all exp 5
PE1(config-egress-queue-exp-map)#commit
PE1(config-egress-queue-exp-map)#exit
PE1(config)#interface ce46/3
PE1(config-if)#label-switching
PE1(config-if)#qos map-profile queue-to-exp exp_profile1
```

5. Define an IP VRF: Create a VRF with Route Distinguisher (RD) and Route Target (RT) to isolate customer routing information.

```
PE1(config)# ip vrf vrf100
PE1(config-vrf)# rd 1.1.1.1:100
PE1(config-vrf)# route-target both 100:100
```

```
PE1(config-vrf)#commit
```

6. Associate Interfaces with VRF: Bind interfaces to the VRF to ensure that the VRF receives the necessary routes.

```
PE1(config)#interface xe0
PE1(config-if)#ip vrf forwarding vrf100
PE1(config-if)#ip address 100.100.100.1/24
PE1(config-if)#exit
PE1(config)#commit
```

7. Configure CE Neighbor for VPN with BGP: Establish a BGP session between the PE router and the CE device, and configure it to advertise routes within the VRF.

```
PE1(config)#router bgp 100
PE1(config-router)# bgp router-id 1.1.1.1
PE1(config-router)#neighbor 3.3.3.3 remote-as 100
PE1(config-router)#neighbor 3.3.3.3 update-source lo
PE1(config-router)#neighbor 3.3.3.3 advertisement-interval 0
PE1(config-router)#address-family ipv4 unicast
PE1(config-router-af)# network 1.1.1.1/32
PE1(config-router-af)#exit-address-family

PE1(config-router)#address-family vpnv4 unicast
PE1(config-router-af)# neighbor 3.3.3.3 activate
PE1(config-router-af)#exit-address-family

PE1(config-router)#address-family ipv4 vrf vrf100
PE1(config-router-af)#redistribute connected
PE1(config-router-af)#neighbor 100.100.100.2 remote-as 100
PE1(config-router-af)#neighbor 100.100.100.2 activate
PE1(config-router-af)#exit-address-family
PE1(config-router)#commit
```

Running Configuration on PE1 Router is as follows:

```
PE1#show running-config
!
! Software version: UFI_S9600-56DX-OcNOS-SP-PLUS-6.5.3.80-Alpha 10/07/2024
14:38:44
!
! Last configuration change at 02:55:39 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile filter qos-ext enable
hardware-profile statistics voq-full-color enable
hardware-profile statistics cfm-ccm disable
hardware-profile port-config mode3
!
qos enable
!
qos profile dscp-to-queue dscp_profile1
 dscp 24 queue 3 dscp 32
```

```
qos profile queue-to-exp exp_profile1
 queue 3 color all exp 5
!
mpls lsp-encap-dscp-preserve
!
hostname PE1
port ce46 breakout 4X10g
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
ip vrf vrf100
 rd 1.1.1.1:100
 route-target both 100:100
!
router ldp
 targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
 transport-address ipv4 1.1.1.1
!
router rsvp
!
interface ce46/3
 load-interval 30
 ip address 10.10.10.1/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 1.1.1.1/32 secondary
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
exit
```

```
!
router ospf 100
 ospf router-id 1.1.1.1
 network 1.1.1.1/32 area 0.0.0.0
 network 10.10.10.0/24 area 0.0.0.0
!
router bgp 100
 bgp router-id 1.1.1.1
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source lo
 neighbor 3.3.3.3 advertisement-interval 0
 !
 address-family ipv4 unicast
 network 1.1.1.1/32
 exit-address-family
 !
 address-family vpnv4 unicast
 neighbor 3.3.3.3 activate
 exit-address-family
 !
 address-family ipv4 vrf vrf100
 redistribute connected
 neighbor 100.100.100.2 remote-as 100
 neighbor 100.100.100.2 activate
 exit-address-family
 !
 exit
!
line console 0
 exec-timeout 0
!
!
end

PE1#
```

Running Configuration on P Router is as follows:

```
P#show running-config
!
! Software version: EC_AS5912-54X-OcNOS-SP-MPLS-6.6.0.104-Alpha 10/13/2024
21:38:49
!
! Last configuration change at 02:00:52 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!
```

```
hostname P
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
router ldp
 transport-address ipv4 2.2.2.2
!
router rsvp
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe1
 load-interval 30
 ip address 10.10.10.2/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
interface xe9
 load-interval 30
 ip address 20.20.20.2/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
exit
!
router ospf 100
 ospf router-id 2.2.2.2
 network 2.2.2.2/32 area 0.0.0.0
```

```
 network 10.10.10.0/24 area 0.0.0.0
 network 20.20.20.0/24 area 0.0.0.0
!
line console 0
 exec-timeout 0
!
!
end

P#
```

Running Configuration on PE2 Router is as follows:

```
PE2#show running-config
!
! Software version: EC_AS7316-26XB-OcNOS-CSR-6.5.3.81-Alpha 10/08/2024
14:39:39
!
! Last configuration change at 07:33:31 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!
hostname PE2
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
ip vrf vrf100
 rd 3.3.3.3:100
 route-target both 100:100
!
router ldp
!
router rsvp
!
```

```
interface ce0
!
interface ce1
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 3.3.3.3/32 secondary
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe4.100
 encapsulation dot1q 100
 load-interval 30
 ip vrf forwarding vrf100
 ip address 200.200.200.1/24
 mtu 9216
!
interface xe9
 load-interval 30
 ip address 20.20.20.1/24
 mtu 9216
 label-switching
 enable-ldp ipv4
!
exit
!
router ospf 100
 ospf router-id 3.3.3.3
 network 3.3.3.3/32 area 0.0.0.0
 network 20.20.20.0/24 area 0.0.0.0
!
router bgp 100
 bgp router-id 3.3.3.3
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source lo
 neighbor 1.1.1.1 advertisement-interval 0
 !
 address-family ipv4 unicast
 network 3.3.3.3/32
 exit-address-family
 !
 address-family vpnv4 unicast
 neighbor 1.1.1.1 activate
 exit-address-family
 !
 address-family ipv4 vrf vrf100
 redistribute connected
 neighbor 200.200.200.2 remote-as 100
 neighbor 200.200.200.2 activate
```

```
 exit-address-family
 !
 exit
!
line console 0
 exec-timeout 0
!
!
end
PE2#
```

Validation

```
Below show command gives us the output of ospf neighborship with transit node.
PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/DR         00:00:37   10.10.10.2     ce46/3                0
PE1#



PE1#sh ip vrf
VRF management, VRF ID: 1, FIB ID 1
MPLS DSCP Preserve Enabled (global)
 Router ID: 10.12.96.29 (automatic)
Interfaces:
  eth0
  lo.management
!
VRF vrf100, VRF ID: 2, FIB ID 2
MPLS DSCP Preserve Enabled (global)
 Router ID: 100.100.100.1 (automatic)
Interfaces:
  lo.vrf100
  xe0.100
!
Total Number of configured IP VRF's: 2
Total Number of all VRF's: 3

Name                               Default RD
management                         not set
vrf100                             1.1.1.1:100
PE1#




PE1#show ip bgp summary
BGP router identifier 100.100.100.1, local AS number 100
BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100
BGP table version is 5
1 BGP AS-PATH entries
```

```
0 BGP community entries

Neighbor           V    AS     MsgRcv     MsgSen  TblVer    InQ   OutQ   Up/Down  State/
PfxRcd   Desc
100.100.100.2      4   100       116        131       5      0      0  00:01:06
10

Total number of neighbors 1

Total number of Established sessions 1
PE1#
```

```
PE1#show ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 3
1 BGP AS-PATH entries
0 BGP community entries

Neighbor           V    AS     MsgRcv     MsgSen  TblVer    InQ   OutQ   Up/Down  State/
PfxRcd   Desc
3.3.3.3           4   100       139        141       2      0      0  00:00:28
1

Total number of neighbors 1

Total number of Established sessions 1

BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100
BGP table version is 5
1 BGP AS-PATH entries
0 BGP community entries

Neighbor           V    AS     MsgRcv     MsgSen  TblVer    InQ   OutQ   Up/Down  State/
PfxRcd   Desc
100.100.100.2      4   100       116        131       5      0      0  00:01:12
10

Total number of neighbors 1

Total number of Established sessions 1
PE1#
```

Below show commands gives us the traffic statistics. Xe0.100 is ingress interface and ce46/3 is the egress interface.

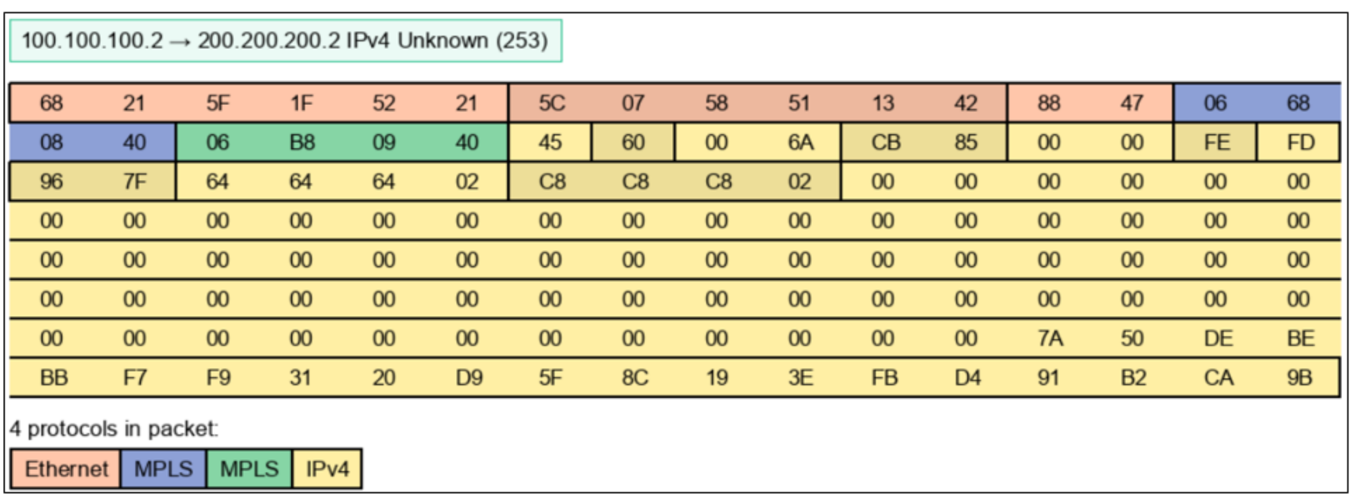
```
PE1#show interface counters rate mbps
+-------------------+--------------+-------------+--------------+-------------+
|     Interface     |   Rx mbps    |   Rx pps    |   Tx mbps    |   Tx pps    |
+-------------------+--------------+-------------+--------------+-------------+
```

```
 ce46/3              0.00          0             10.36          9810
 xe0                 10.21         9969          0.00           0
 xe0.100             10.25         10007         0.00           0
PE1#
```

Below show command gives us the queue-stats on the egress interface of the ingress node. From the configuration made, the traffic is expected to flow in queue 3 as shown below.

```
PE1#show interface ce46/3 counters queue-stats
E - Egress, I - Ingress, Q-Size is in bytes
+--------------------+--------+-----------------+-------------------+-----------------
+--------------------+
|   Queue/Class-map  | Q-Size |     Tx pkts     |     Tx bytes      |  Dropped pkts   |
Dropped bytes    |
+--------------------+--------+-----------------+-------------------+-----------------
+--------------------+
q0                  (E)  12499968 0                 0                    0                  0
q1                  (E)  12499968 0                 0                    0                  0
q2                  (E)  12499968 0                 0                    0                  0
q3                 (E)  12499968 7931421           872455900            0                  0
q4                  (E)  12499968 0                 0                    0                  0
q5                  (E)  12499968 0                 0                    0                  0
q6                  (E)  12499968 377               30275                0                  0
q7                  (E)  12499968 252               14180                0                  0

PE1#
```

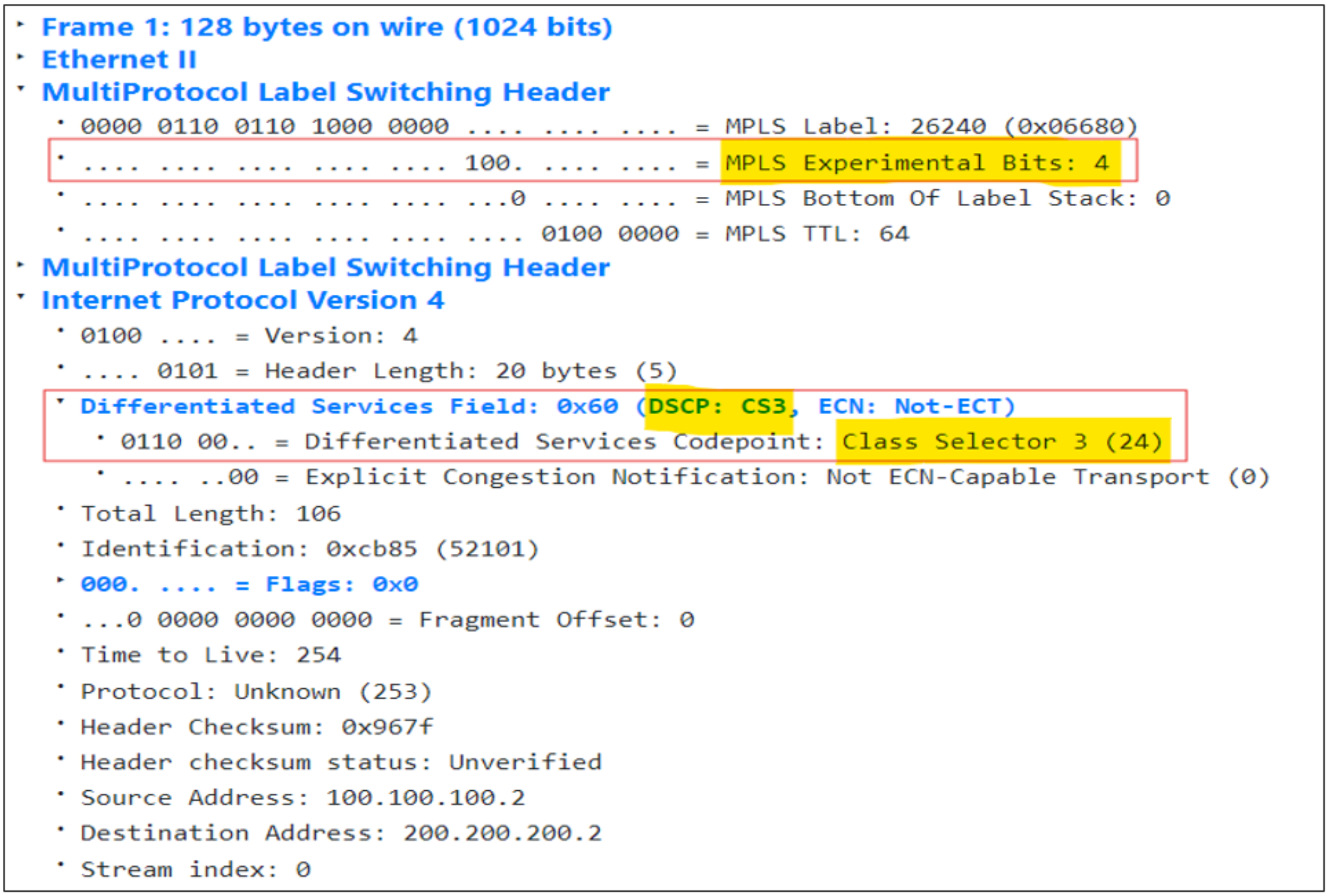
Once the end to end traffic is verified, capture the packet on egress interface of the ingress node. Below is the example packet capture.


100.100.100.2 → 200.200.200.2 IPv4 Unknown (253)

68	21	5F	1F	52	21	5C	07	58	51	13	42	88	47	06	68
08	40	06	B8	09	40	45	60	00	6A	CB	85	00	00	FE	FD
96	7F	64	64	64	02	C8	C8	C8	02	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	7A	50	DE	BE
BB	F7	F9	31	20	D9	5F	8C	19	3E	FB	D4	91	B2	CA	9B

4 protocols in packet:
Ethernet MPLS MPLS IPv4

Below snapshot is the decoded output of the packet capture. Here we can see that EXP bit is 4 and preserved DSCP value is 24.



```
Frame 1: 128 bytes on wire (1024 bits)
Ethernet II
MultiProtocol Label Switching Header
  0000 0110 0110 1000 0000 .... .... .... = MPLS Label: 26240 (0x06680)
  .... .... .... .... .... 100. .... .... = MPLS Experimental Bits: 4
  .... .... .... .... .... ...0 .... .... = MPLS Bottom Of Label Stack: 0
  .... .... .... .... .... .... 0100 0000 = MPLS TTL: 64
MultiProtocol Label Switching Header
Internet Protocol Version 4
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
  Differentiated Services Field: 0x60 (DSCP: CS3, ECN: Not-ECT)
    0110 00.. = Differentiated Services Codepoint: Class Selector 3 (24)
    .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
  Total Length: 106
  Identification: 0xcb85 (52101)
  000. .... = Flags: 0x0
  ...0 0000 0000 0000 = Fragment Offset: 0
  Time to Live: 254
  Protocol: Unknown (253)
  Header Checksum: 0x967f
  Header checksum status: Unverified
  Source Address: 100.100.100.2
  Destination Address: 200.200.200.2
  Stream index: 0
```

```
PE1#show qos-profile type dscp-to-queue dscp_profile1
profile name: dscp_profile1
profile type: dscp-to-queue
profile attached to 1 instances
configured mapping:
 dscp 24 queue 3 dscp 32
Detailed mapping:
 -------+-------------------------- | -------+-------------------------- | -------+--
------------------------- | -------+--------------------------
  INPUT |        OUTPUT             |  INPUT |        OUTPUT             |  INPUT |
OUTPUT                  |  INPUT |         OUTPUT
 -------+-------------------------- | -------+-------------------------- | -------+--
------------------------- | -------+--------------------------
  DSCP  |    TC   | Color   |remark DSCP|  DSCP   |    TC   | Color   |remark DSCP|  DSCP   |
TC   | Color   |remark DSCP|  DSCP   |    TC   | Color   |remark DSCP
        |         |         |   (TC)    |         |         |         |   (TC)    |         |
|        |   (TC)    |         |         |         |   (TC)
 -------+-------+--------+---------- | -------+-------+--------+---------- | -------+--
-----+--------+---------- | -------+-------+--------+----------
   0      0      green     0 (0)    |  16      2      green    16 (2)    |  32      4
green    32 (4)    |  48      6      green    48 (6)
   1      0      green     1 (0)    |  17      2      green    17 (2)    |  33      4
green    33 (4)    |  49      6      green    49 (6)
```

```
  2     0      green     2 (0)    | 18     2       green    18 (2)    |  34     4
green    34 (4)    |  50      6       green    50 (6)
  3     0      green     3 (0)    | 19     2       green    19 (2)    |  35     4
green    35 (4)    |  51      6       green    51 (6)
  4     0      green     4 (0)    | 20     2       yellow   20 (2)    |  36     4
yellow   36 (4)    |  52      6       green    52 (6)
  5     0      green     5 (0)    | 21     2       green    21 (2)    |  37     4
green    37 (4)    |  53      6       green    53 (6)
  6     0      green     6 (0)    | 22     2       yellow   22 (2)    |  38     4
yellow   38 (4)    |  54      6       green    54 (6)
  7     0      green     7 (0)    | 23     2       green    23 (2)    |  39     4
green    39 (4)    |  55      6       green    55 (6)
  8     1      green     8 (1)    | 24     3       green    32 (4)    |  40     5
green    40 (5)    |  56      7       green    56 (7)
  9     1      green     9 (1)    | 25     3       green    25 (3)    |  41     5
green    41 (5)    |  57      7       green    57 (7)
 10     1      green    10 (1)    | 26     3       green    26 (3)    |  42     5
green    42 (5)    |  58      7       green    58 (7)
 11     1      green    11 (1)    | 27     3       green    27 (3)    |  43     5
green    43 (5)    |  59      7       green    59 (7)
 12     1      yellow   12 (1)    | 28     3       yellow   28 (3)    |  44     5
green    44 (5)    |  60      7       green    60 (7)
 13     1      green    13 (1)    | 29     3       green    29 (3)    |  45     5
green    45 (5)    |  61      7       green    61 (7)
 14     1      yellow   14 (1)    | 30     3       yellow   30 (3)    |  46     5
green    46 (5)    |  62      7       green    62 (7)
 15     1      green    15 (1)    | 31     3       green    31 (3)    |  47     5
green    47 (5)    |  63      7       green    63 (7)

PE1#
```

```
PE1#show qos-profile interface ce46/3
profile name: default
 profile type: dscp-to-queue (Ingress)
 mapping:
 -------+--------------------------- | -------+--------------------------- | -------+--
------------------------- | -------+---------------------------
  INPUT |        OUTPUT            |  INPUT |        OUTPUT            |  INPUT |
OUTPUT             |  INPUT |        OUTPUT
 -------+--------------------------- | -------+--------------------------- | -------+--
------------------------- | -------+---------------------------
  DSCP  |   TC  | Color  |remark DSCP|  DSCP  |   TC  | Color  |remark DSCP|  DSCP  |
TC  | Color  |remark DSCP|  DSCP  |   TC  | Color  |remark DSCP
       |       |        |   (TC)    |        |       |        |   (TC)    |        |
|       |   (TC)    |        |       |        |   (TC)
 -------+-------+--------+---------- | -------+-------+--------+---------- | -------+--
-----+--------+---------- | -------+-------+--------+----------
  0     0      green     0 (0)    | 16     2       green    16 (2)    |  32     4
green    32 (4)    |  48      6       green    48 (6)
  1     0      green     1 (0)    | 17     2       green    17 (2)    |  33     4
green    33 (4)    |  49      6       green    49 (6)
  2     0      green     2 (0)    | 18     2       green    18 (2)    |  34     4
green    34 (4)    |  50      6       green    50 (6)
```

```
   3      0       green     3 (0)    |  19      2       green    19 (2)    |  35      4
green    35 (4)    |  51       6       green    51 (6)
   4      0       green     4 (0)    |  20      2       yellow   20 (2)    |  36      4
yellow   36 (4)    |  52       6       green    52 (6)
   5      0       green     5 (0)    |  21      2       green    21 (2)    |  37      4
green    37 (4)    |  53       6       green    53 (6)
   6      0       green     6 (0)    |  22      2       yellow   22 (2)    |  38      4
yellow   38 (4)    |  54       6       green    54 (6)
   7      0       green     7 (0)    |  23      2       green    23 (2)    |  39      4
green    39 (4)    |  55       6       green    55 (6)
   8      1       green     8 (1)    |  24      3       green    24 (3)    |  40      5
green    40 (5)    |  56       7       green    56 (7)
   9      1       green     9 (1)    |  25      3       green    25 (3)    |  41      5
green    41 (5)    |  57       7       green    57 (7)
  10      1       green    10 (1)    |  26      3       green    26 (3)    |  42      5
green    42 (5)    |  58       7       green    58 (7)
  11      1       green    11 (1)    |  27      3       green    27 (3)    |  43      5
green    43 (5)    |  59       7       green    59 (7)
  12      1       yellow   12 (1)    |  28      3       yellow   28 (3)    |  44      5
green    44 (5)    |  60       7       green    60 (7)
  13      1       green    13 (1)    |  29      3       green    29 (3)    |  45      5
green    45 (5)    |  61       7       green    61 (7)
  14      1       yellow   14 (1)    |  30      3       yellow   30 (3)    |  46      5
green    46 (5)    |  62       7       green    62 (7)
  15      1       green    15 (1)    |  31      3       green    31 (3)    |  47      5
green    47 (5)    |  63       7       green    63 (7)

profile name: default
 profile type: dscp-to-dscp (Egress)
 Status: Inactive
mapping:
 -----------------------+---------- | -----------------------+---------- | ------------
-----------+----------
        INPUT          |  OUTPUT   |        INPUT          |  OUTPUT   |        INPUT
|  OUTPUT
 -----------------------+---------- | -----------------------+---------- | ------------
-----------+----------
  Remark DSCP |  Color   | Out DSCP  |  Remark DSCP |  Color   | Out DSCP  |  Remark DSCP
|  Color   | Out DSCP
      (TC)    |         |          |     (TC)    |         |          |     (TC)    |
|
 -------------+---------+---------- | -------------+---------+---------- | ------------
-+---------+----------
   0  (0)        green            0 |   0  (0)        yellow           0 |   0  (0)
red               0
   1  (0)        green            1 |   1  (0)        yellow           1 |   1  (0)
red               1
   2  (0)        green            2 |   2  (0)        yellow           2 |   2  (0)
red               2
   3  (0)        green            3 |   3  (0)        yellow           3 |   3  (0)
red               3
   4  (0)        green            4 |   4  (0)        yellow           4 |   4  (0)
red               4
   5  (0)        green            5 |   5  (0)        yellow           5 |   5  (0)
red               5
```

```
   6 (0)         green            6 |   6 (0)        yellow           6 |   6 (0)
red               6
   7 (0)         green            7 |   7 (0)        yellow           7 |   7 (0)
red               7
   8 (1)         green            8 |   8 (1)        yellow           8 |   8 (1)
red               8
   9 (1)         green            9 |   9 (1)        yellow           9 |   9 (1)
red               9
  10 (1)         green           10 |  10 (1)        yellow          12 |  10 (1)
red              14
  11 (1)         green           11 |  11 (1)        yellow          11 |  11 (1)
red              11
  12 (1)         green           12 |  12 (1)        yellow          12 |  12 (1)
red              14
  13 (1)         green           13 |  13 (1)        yellow          13 |  13 (1)
red              13
  14 (1)         green           14 |  14 (1)        yellow          14 |  14 (1)
red              14
  15 (1)         green           15 |  15 (1)        yellow          15 |  15 (1)
red              15
  16 (2)         green           16 |  16 (2)        yellow          16 |  16 (2)
red              16
  17 (2)         green           17 |  17 (2)        yellow          17 |  17 (2)
red              17
  18 (2)         green           18 |  18 (2)        yellow          20 |  18 (2)
red              22
  19 (2)         green           19 |  19 (2)        yellow          19 |  19 (2)
red              19
  20 (2)         green           20 |  20 (2)        yellow          20 |  20 (2)
red              22
  21 (2)         green           21 |  21 (2)        yellow          21 |  21 (2)
red              21
  22 (2)         green           22 |  22 (2)        yellow          22 |  22 (2)
red              22
  23 (2)         green           23 |  23 (2)        yellow          23 |  23 (2)
red              23
  24 (3)         green           24 |  24 (3)        yellow          24 |  24 (3)
red              24
  25 (3)         green           25 |  25 (3)        yellow          25 |  25 (3)
red              25
  26 (3)         green           26 |  26 (3)        yellow          28 |  26 (3)
red              30
  27 (3)         green           27 |  27 (3)        yellow          27 |  27 (3)
red              27
  28 (3)         green           28 |  28 (3)        yellow          28 |  28 (3)
red              30
  29 (3)         green           29 |  29 (3)        yellow          29 |  29 (3)
red              29
  30 (3)         green           30 |  30 (3)        yellow          30 |  30 (3)
red              30
  31 (3)         green           31 |  31 (3)        yellow          31 |  31 (3)
red              31
  32 (4)         green           32 |  32 (4)        yellow          32 |  32 (4)
red              32
  33 (4)         green           33 |  33 (4)        yellow          33 |  33 (4)
red              33
```

```
  34 (4)        green         34 |  34 (4)      yellow        36 |  34 (4)
red               38
  35 (4)        green         35 |  35 (4)      yellow        35 |  35 (4)
red               35
  36 (4)        green         36 |  36 (4)      yellow        36 |  36 (4)
red               38
  37 (4)        green         37 |  37 (4)      yellow        37 |  37 (4)
red               37
  38 (4)        green         38 |  38 (4)      yellow        38 |  38 (4)
red               38
  39 (4)        green         39 |  39 (4)      yellow        39 |  39 (4)
red               39
  40 (5)        green         40 |  40 (5)      yellow        40 |  40 (5)
red               40
  41 (5)        green         41 |  41 (5)      yellow        41 |  41 (5)
red               41
  42 (5)        green         42 |  42 (5)      yellow        42 |  42 (5)
red               42
  43 (5)        green         43 |  43 (5)      yellow        43 |  43 (5)
red               43
  44 (5)        green         44 |  44 (5)      yellow        44 |  44 (5)
red               44
  45 (5)        green         45 |  45 (5)      yellow        45 |  45 (5)
red               45
  46 (5)        green         46 |  46 (5)      yellow        46 |  46 (5)
red               46
  47 (5)        green         47 |  47 (5)      yellow        47 |  47 (5)
red               47
  48 (6)        green         48 |  48 (6)      yellow        48 |  48 (6)
red               48
  49 (6)        green         49 |  49 (6)      yellow        49 |  49 (6)
red               49
  50 (6)        green         50 |  50 (6)      yellow        50 |  50 (6)
red               50
  51 (6)        green         51 |  51 (6)      yellow        51 |  51 (6)
red               51
  52 (6)        green         52 |  52 (6)      yellow        52 |  52 (6)
red               52
  53 (6)        green         53 |  53 (6)      yellow        53 |  53 (6)
red               53
  54 (6)        green         54 |  54 (6)      yellow        54 |  54 (6)
red               54
  55 (6)        green         55 |  55 (6)      yellow        55 |  55 (6)
red               55
  56 (7)        green         56 |  56 (7)      yellow        56 |  56 (7)
red               56
  57 (7)        green         57 |  57 (7)      yellow        57 |  57 (7)
red               57
  58 (7)        green         58 |  58 (7)      yellow        58 |  58 (7)
red               58
  59 (7)        green         59 |  59 (7)      yellow        59 |  59 (7)
red               59
  60 (7)        green         60 |  60 (7)      yellow        60 |  60 (7)
red               60
  61 (7)        green         61 |  61 (7)      yellow        61 |  61 (7)
red               61
```

```
  62 (7)        green           62 |  62 (7)        yellow          62 |  62 (7)
red               62
  63 (7)        green           63 |  63 (7)        yellow          63 |  63 (7)
red               63

PE1#
```

CLI Commands

The DSCP preserve introduces the following configuration commands.

mpls lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when dscp is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the no parameter with this to unconfigure DSCP preserve.

Note: In Qumran1 devices, DSCP preserve feature is not supported when the transport is Segment Routing.

Command Syntax

```
mpls lsp-encap-dscp-preserve
no mpls lsp-encap-dscp-preserve
```

Default

By default, mpls local packet handling is disabled

Parameters

None

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 6.5.2 for Qumran 1. Extended the support for Qumran 2 in OcNOS version 6.5.3.

Examples

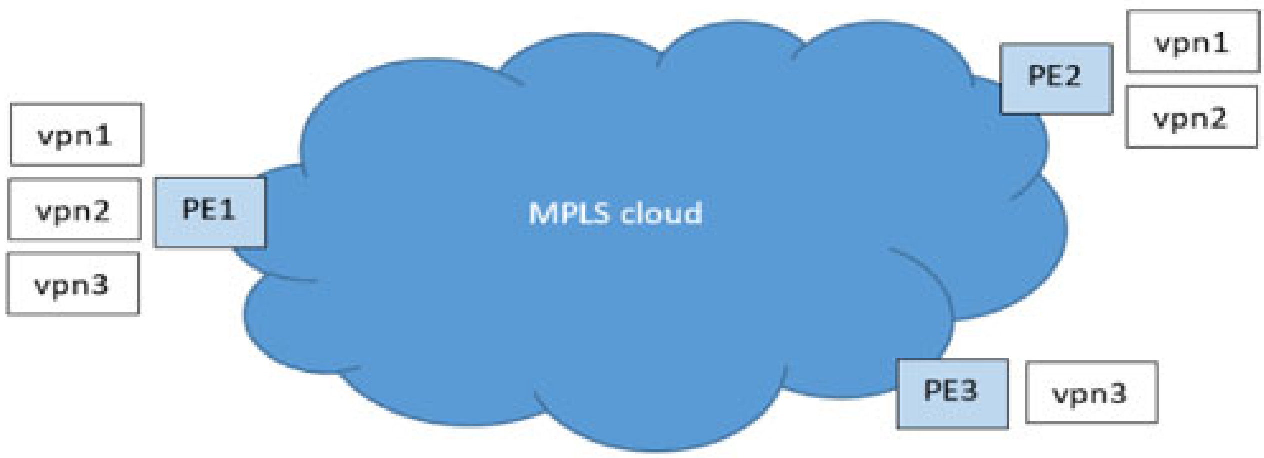
```
#configure terminal
(config)#mpls lsp-encap-dscp-preserve
(config)#commit

#configure terminal
(config)#no mpls lsp-encap-dscp-preserve
(config)#commit
```

DSCP Preserve Per-VRF

This method of configuration allows Network operator to enable or disable DSCP preserve for specific L3 VPN services in an edge router.

DSCP Preserve Per-VRF Characteristics

The MPLS cloud connects edge routers that provision L3 VPN services for multiple customers. Each edge router can support multiple VPN services, with different QoS (DSCP) remarking needs. Some customers may want to retain the DSCP field in the IP header, while others may need to update it as traffic enters the MPLS network. By default, the DSCP field in customer packets is not preserved when remarking occurs.



Prerequisites

The L3VPN service will operate seamlessly from end to end without any packet loss, using either OSPF or IS-IS as the IGP, with traffic profiles configured based on user-defined DSCP values.

- Global level configuration for PE1:

```
config t
qos enable
!
qos profile dscp-to-queue profile1
dscp 24 queue 3 dscp 32
```

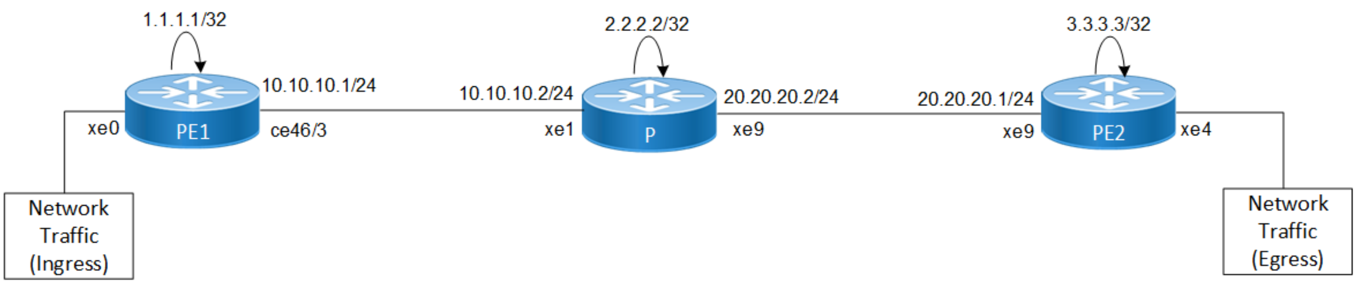
- interface level configuration for PE1:

```
interface xe3
qos map-profile dscp-to-queue profile1
!
```

Configuration for DSCP Preserve Per-VRF

Topology

The topology illustrates the DSCP preserve feature, with PE1 and PE2 as the edge routers running L3VPN services, and the P router functioning as a transit router between them. PE1 receiving L3VPN and 6PE traffic with user-defined DSCP values, which can be either preserved or modified depending on the configurations applied at the ingress PE router. Multiple VRFs will be configured, each representing a different customer, where DSCP-preserve can be enabled or disabled at the per-VRF level.



Per- VRF DSCP Preserve

Configure DSCP Preserve and L3VPN Services on PE1 Router

1. Enable QoS Globally: This command is mandatory to configure any QoS-related settings. Without it, QoS configurations will not function.

```
PE1(config)# qos enable
PE1(config)# commit
```

2. (Optional) Configure DSCP Preserve globally for L3VPN and 6PE Traffic: This command provides control over remarking user-defined DSCP values. Enabling this will preserve the DSCP value throughout the network. If DSCP preserve to be enabled only for specific L3 VPN services, then this command need not to be configured.

```
PE1(config)#mpls lsp-encap-dscp-preserve
```

3. Configure DSCP Preserve globally for 6PE Traffic: This command provides control over remarking user-defined DSCP values. Enabling this will preserve the DSCP value throughout the network.

```
PE1(config)# mpls 6pe lsp-encap-dscp-preserve (enable | disable)
```

4. Configure QoS Profiles or Class-Map Profiles for remarking incoming DSCP values as follows:

   - Method 1: QoS Profile: Use the “dscp-to-queue” profile to remark the incoming DSCP value via a user-defined queue.

```
PE1(config)# qos profile dscp-to-queue dscp_profile1
PE1(config-ingress-dscp-map)# dscp 24 queue 3 dscp 32
PE1(config-ingress-dscp-map)# commit
PE1(config-ingress-dscp-map)# exit
PE1(config)# interface xe0.100
PE1(config-if)# qos map-profile dscp-to-queue dscp_profile1
PE1(config-if)# commit
PE1(config-if)# exit
```

   - Method 2: Class-Map/Policy-Map: Use the “match” criteria to remark the incoming DSCP value to a user-defined DSCP value.

```
PE1(config)# class-map type qos match-any class1
PE1(config-qos-match-any)# match dscp 24
```

```
PE1(config-qos-match-any)# commit
PE1(config-qos-match-any)# exit
PE1(config)# policy-map type qos pmap1
PE1(config-pmap-qos)# class type qos class1
PE1(config-pmap-qos)# set dscp 32
PE1(config-pmap-qos)# commit
PE1(config-pmap-qos)# exit
PE1(config)# interface xe0.100
PE1(config-if)# service-policy type qos input pmap1
PE1(config-if)# commit
```

5. Configure EXP Encapsulation on the Egress Interface: This profile modifies the incoming EXP value to the user-defined EXP value, which is then reflected in the MPLS EXP bit.
   - Example Config on Qumran 1:

```
PE1(config)# qos profile exp-encap exp_profile1
PE1(config-egress-exp-encap-map)# l3 dscp 32 exp 5
PE1(config-egress-exp-encap-map)# commit
PE1(config-egress-exp-encap-map)# exit
PE1(config)# interface ce46/3
PE1(config-if)# label-switching
PE1(config-if)# qos map-profile exp-encap exp_profile1
PE1(config-if)# commit
PE1(config-if)# exit
```

   - Example Config on Qumran 2:

```
PE1(config)# qos profile queue-to-exp exp_profile1
PE1(config-egress-queue-exp-map)# queue 3 color all exp 5
PE1(config-egress-queue-exp-map)# commit
PE1(config-egress-queue-exp-map)# exit
PE1(config)# interface ce46/3
PE1(config-if)# label-switching
PE1(config-if)# qos map-profile queue-to-exp exp_profile1
```

6. Define Multiple IP VRFs: Configure VRFs with appropriate Route Distinguisher (RD) and Route Target (RT) values to isolate IP address routing for multiple customers.

```
PE1(config)# ip vrf vrf100
PE1(config-vrf)# rd 1.1.1.1:100
PE1(config-vrf)# route-target both 100:100
PE1(config-vrf)# commit

PE1(config)# ip vrf vrf101
PE1(config-vrf)# rd 1.1.1.1:101
PE1(config-vrf)# route-target both 101:101
PE1(config-vrf)# commit

PE1(config)# ip vrf vrf102
PE1(config-vrf)# rd 1.1.1.1:102
PE1(config-vrf)# route-target both 102:102
PE1(config-vrf)# commit
```

7. Associate Interfaces to VRFs: After defining the VRFs, assign interfaces to them to allow the PE router to recognize which interfaces belong to each VRF.

```
PE1(config)# interface xe0.100
PE1(config-if)# encapsulation dot1q 100
PE1(config-if)# ip vrf forwarding vrf100
PE1(config-if)# ip address 100.100.100.1/24
PE1(config-if)# exit
```

```
PE1(config)# commit

PE1(config)# interface xe0.101
PE1(config-if)# encapsulation dot1q 101
PE1(config-if)# ip vrf forwarding vrf101
PE1(config-if)# ip address 100.100.101.1/24
PE1(config-if)# exit
PE1(config)# commit

PE1(config)# interface xe0.102
PE1(config-if)# encapsulation dot1q 102
PE1(config-if)# ip vrf forwarding vrf102
PE1(config-if)# ip address 100.100.102.1/24
PE1(config-if)# exit
PE1(config)# commit

PE1(config)# interface xe0.103
PE1(config-if)# encapsulation dot1q 103
PE1(config-if)# ipv6 address 1001::2/64
PE1(config-if)# exit
PE1(config)# commit
```

8. Configure CE Neighbor for VPN Using BGP: To provide a VPN service, configure the PE router to associate any routing information learned from a VPN customer interface with a particular VRF.

```
PE1(config)# router bgp 100
PE1(config)# bgp router-id 1.1.1.1
PE1(config)# neighbor 3.3.3.3 remote-as 100
PE1(config)# neighbor 3.3.3.3 update-source lo
PE1(config)# neighbor 3.3.3.3 advertisement-interval 0
PE1(config)# neighbor 1001::2 remote-as 100
PE1(config-router)# address-family ipv4 unicast
PE1(config-router-af)# redistribute connected
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv4 vrf vrf100
PE1(config-router)# neighbor 100.100.100.2 remote-as 100
PE1(config-router-af)# neighbor 100.100.100.2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv4 vrf vrf101
PE1(config-router)# neighbor 100.100.101.2 remote-as 100
PE1(config-router-af)# neighbor 100.100.101.2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv4 vrf vrf102
PE1(config-router)# neighbor 100.100.102.2 remote-as 100
PE1(config-router-af)# neighbor 100.100.102.2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# address-family ipv6 unicast
PE1(config-router-af)# neighbor 1001::2 activate
PE1(config-router-af)# exit-address-family
PE1(config-router)# commit
```

9. Now enable or disable dscp-preserve based on requirement globally and per-vrf level for L3VPN and 6PE traffic.

```
PE1(config)#ip vrf vrf100
PE1(config-vrf)#mpls lsp-encap-dscp-preserve enable
PE1(config)#ip vrf vrf101
PE1(config-vrf)#mpls lsp-encap-dscp-preserve disable
PE1(config)#ip vrf vrf102
PE1(config-vrf)#mpls lsp-encap-dscp-preserve enable
```

Running Configuration on PE1 Router is as follows:

```
PE1#show running-config
!
! Software version: UFI_S9600-56DX-OcNOS-SP-PLUS-6.5.3.80-Alpha 10/07/2024
14:38:44
!
! Last configuration change at 02:55:39 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile filter qos-ext enable
hardware-profile statistics voq-full-color enable
hardware-profile statistics cfm-ccm disable
hardware-profile port-config mode3
!
qos enable
qos profile dscp-to-queue dscp_profile1
 dscp 24 queue 3 dscp 32
qos profile queue-to-exp exp_profile1
 queue 3 color all exp 5
!
mpls lsp-encap-dscp-preserve
!
hostname PE1
port ce46 breakout 4X10g
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
ip vrf vrf100
 rd 1.1.1.1:100
 route-target both 100:100
!
router ldp
 targeted-peer ipv4 3.3.3.3
  exit-targeted-peer-mode
 transport-address ipv4 1.1.1.1
!
```

```
router rsvp
!
interface ce46/3
 load-interval 30
 ip address 10.10.10.1/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 1.1.1.1/32 secondary
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
exit
!
router ospf 100
 ospf router-id 1.1.1.1
 network 1.1.1.1/32 area 0.0.0.0
 network 10.10.10.0/24 area 0.0.0.0
!
router bgp 100
 bgp router-id 1.1.1.1
 neighbor 3.3.3.3 remote-as 100
 neighbor 3.3.3.3 update-source lo
 neighbor 3.3.3.3 advertisement-interval 0
 !
 address-family ipv4 unicast
 network 1.1.1.1/32
 exit-address-family
 !
 address-family vpnv4 unicast
 neighbor 3.3.3.3 activate
 exit-address-family
 !
 address-family ipv4 vrf vrf100
 redistribute connected
 neighbor 100.100.100.2 remote-as 100
 neighbor 100.100.100.2 activate
 exit-address-family
 !
 exit
!
line console 0
 exec-timeout 0
!
!
```

```
end

PE1#
```

Running Configuration on P Router is as follows:

```
P#show running-config
!
! Software version: EC_AS5912-54X-OcNOS-SP-MPLS-6.6.0.104-Alpha 10/13/2024
21:38:49
!
! Last configuration change at 02:00:52 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!
hostname P
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
router ldp
 transport-address ipv4 2.2.2.2
!
router rsvp
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128
!
```

```
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe1
 load-interval 30
 ip address 10.10.10.2/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
interface xe9
 load-interval 30
 ip address 20.20.20.2/24
 mtu 9216
 label-switching
 enable-ldp ipv4
 enable-rsvp
!
exit
!
router ospf 100
 ospf router-id 2.2.2.2
 network 2.2.2.2/32 area 0.0.0.0
 network 10.10.10.0/24 area 0.0.0.0
 network 20.20.20.0/24 area 0.0.0.0
!
line console 0
 exec-timeout 0
!
!
end

P#
```

Running Configuration on PE2 Router is as follows:

```
PE2#show running-config
!
! Software version: EC_AS7316-26XB-OcNOS-CSR-6.5.3.81-Alpha 10/08/2024
14:39:39
!
! Last configuration change at 07:33:31 UTC Tue Oct 15 2024 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
```

```
!
hostname PE2
no ip domain-lookup
ip domain-lookup vrf management
tfo Disable
errdisable cause stp-bpdu-guard
no feature telnet vrf management
no feature telnet
feature ssh vrf management
no feature ssh
feature dns relay
ip dns relay
ipv6 dns relay
feature ntp vrf management
ntp enable vrf management
!
ip vrf management
!
ip vrf vrf100
 rd 3.3.3.3:100
 route-target both 100:100
!
router ldp
!
router rsvp
!
interface ce0
!
interface ce1
!
interface eth0
 ip vrf forwarding management
 ip address dhcp
!
interface lo
 ip address 127.0.0.1/8
 ip address 3.3.3.3/32 secondary
 ipv6 address ::1/128
!
interface lo.management
 ip vrf forwarding management
 ip address 127.0.0.1/8
 ipv6 address ::1/128
!
interface xe4.100
 encapsulation dot1q 100
 load-interval 30
 ip vrf forwarding vrf100
 ip address 200.200.200.1/24
 mtu 9216
!
interface xe9
 load-interval 30
 ip address 20.20.20.1/24
 mtu 9216
 label-switching
 enable-ldp ipv4
```

```
!
exit
!
router ospf 100
 ospf router-id 3.3.3.3
 network 3.3.3.3/32 area 0.0.0.0
 network 20.20.20.0/24 area 0.0.0.0
!
router bgp 100
 bgp router-id 3.3.3.3
 neighbor 1.1.1.1 remote-as 100
 neighbor 1.1.1.1 update-source lo
 neighbor 1.1.1.1 advertisement-interval 0
 !
 address-family ipv4 unicast
 network 1.1.1.1/32
 exit-address-family
 !
 address-family vpnv4 unicast
 neighbor 1.1.1.1 activate
 exit-address-family
 !
 address-family ipv4 vrf vrf100
 redistribute connected
 neighbor 200.200.200.2 remote-as 100
 neighbor 200.200.200.2 activate
 exit-address-family
 !
 exit
!
line console 0
 exec-timeout 0
!
!
end
PE2#
```

Validation

```
PE1#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/DR         00:00:37   10.10.10.2      ce46/3              0
PE1#


PE1#sh ip vrf
VRF management, VRF ID: 1, FIB ID 1
MPLS DSCP Preserve Enabled (global)
 Router ID: 10.12.96.29 (automatic)
Interfaces:
  eth0
  lo.management
```

```
!
VRF vrf100, VRF ID: 2, FIB ID 2
MPLS DSCP Preserve Enabled (global)
 Router ID: 100.100.100.1 (automatic)
Interfaces:
  lo.vrf100
  xe0.100
!
Total Number of configured IP VRF's: 2
Total Number of all VRF's: 3

Name                                Default RD
management                          not set
vrf100                              1.1.1.1:100
PE1#

PE1#show ip bgp summary
BGP router identifier 100.100.100.1, local AS number 100
BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100
BGP table version is 5
1 BGP AS-PATH entries
0 BGP community entries

Neighbor           V    AS     MsgRcv     MsgSen  TblVer    InQ   OutQ   Up/Down  State/
PfxRcd   Desc
100.100.100.2     4   100       116        131       5      0      0  00:01:06
10

Total number of neighbors 1

Total number of Established sessions 1
PE1#


PE1#show ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 3
1 BGP AS-PATH entries
0 BGP community entries

Neighbor           V    AS     MsgRcv     MsgSen  TblVer    InQ   OutQ   Up/Down  State/
PfxRcd   Desc
3.3.3.3           4   100       139        141       2      0      0  00:00:28
1

Total number of neighbors 1

Total number of Established sessions 1

BGP VRF vrf100 Route Distinguisher: 1.1.1.1:100
BGP table version is 5
```

```
1 BGP AS-PATH entries
0 BGP community entries

Neighbor          V    AS     MsgRcv     MsgSen  TblVer    InQ   OutQ   Up/Down  State/
PfxRcd   Desc
100.100.100.2     4   100       116        131       5      0      0  00:01:12
10

Total number of neighbors 1

Total number of Established sessions 1
PE1#

PE1#show interface counters rate mbps
+-------------------+--------------+-------------+--------------+-------------+
|     Interface     |    Rx mbps   |    Rx pps   |    Tx mbps   |    Tx pps   |
+-------------------+--------------+-------------+--------------+-------------+
 ce46/3              0.00          0             10.36          9810
 xe0                 10.21         9969          0.00           0
 xe0.100             10.25         10007         0.00           0
PE1#

PE1#show interface ce46/3 counters queue-stats
E - Egress, I - Ingress, Q-Size is in bytes
+--------------------+--------+-----------------+-------------------+-----------------
+-------------------+
|   Queue/Class-map  | Q-Size |     Tx pkts     |     Tx bytes      |  Dropped pkts   |
Dropped bytes   |
+--------------------+--------+-----------------+-------------------+-----------------
+-------------------+
q0                 (E) 12499968 0                0                   0                  0
q1                 (E) 12499968 0                0                   0                  0
q2                 (E) 12499968 0                0                   0                  0
q3                 (E) 12499968 7931421          872455900           0                  0
q4                 (E) 12499968 0                0                   0                  0
q5                 (E) 12499968 0                0                   0                  0
q6                 (E) 12499968 377              30275               0                  0
q7                 (E) 12499968 252              14180               0                  0

PE1#
```

Once the end to end traffic is verified, capture the packet on egress interface of the ingress node. Below is the example packet capture.

100.100.100.2 → 200.200.200.2 IPv4 Unknown (253)

68	21	5F	1F	52	21	5C	07	58	51	13	42	88	47	06	68
08	40	06	B8	09	40	45	60	00	6A	CB	85	00	00	FE	FD
96	7F	64	64	64	02	C8	C8	C8	02	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	7A	50	DE	BE
BB	F7	F9	31	20	D9	5F	8C	19	3E	FB	D4	91	B2	CA	9B

4 protocols in packet:

Ethernet | MPLS | MPLS | IPv4

Below snapshot is the decoded output of the packet capture. Here we can see that EXP bit is 4 and preserved DSCP value is 24.

```
Frame 1: 128 bytes on wire (1024 bits)
Ethernet II
MultiProtocol Label Switching Header
    0000 0110 0110 1000 0000 .... .... .... = MPLS Label: 26240 (0x06680)
    .... .... .... .... .... 100. .... .... = MPLS Experimental Bits: 4
    .... .... .... .... .... ...0 .... .... = MPLS Bottom Of Label Stack: 0
    .... .... .... .... .... .... 0100 0000 = MPLS TTL: 64
MultiProtocol Label Switching Header
Internet Protocol Version 4
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
    Differentiated Services Field: 0x60 (DSCP: CS3, ECN: Not-ECT)
        0110 00.. = Differentiated Services Codepoint: Class Selector 3 (24)
        .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
    Total Length: 106
    Identification: 0xcb85 (52101)
    000. .... = Flags: 0x0
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 254
    Protocol: Unknown (253)
    Header Checksum: 0x967f
    Header checksum status: Unverified
    Source Address: 100.100.100.2
    Destination Address: 200.200.200.2
    Stream index: 0
```

```
PE1#show qos-profile type dscp-to-queue dscp_profile1
profile name: dscp_profile1
```

```
profile type: dscp-to-queue
profile attached to 1 instances
configured mapping:
 dscp 24 queue 3 dscp 32
Detailed mapping:
 -------+--------------------------- | -------+--------------------------- | -
------+--------------------------- | -------+---------------------------
  INPUT |         OUTPUT             |  INPUT |         OUTPUT             |
INPUT |         OUTPUT             |  INPUT |         OUTPUT
 -------+--------------------------- | -------+--------------------------- | -
------+--------------------------- | -------+---------------------------
  DSCP  |   TC  | Color  |remark DSCP|  DSCP  |   TC  | Color  |remark DSCP|
DSCP  |   TC  | Color  |remark DSCP|  DSCP  |   TC  | Color  |remark DSCP
       |       |        |   (TC)    |        |       |        |   (TC)    |
|       |       |        |   (TC)    |        |       |        |   (TC)
 -------+-------+--------+---------- | -------+-------+--------+---------- | -
------+-------+--------+---------- | -------+-------+--------+----------
   0      0       green     0 (0)    |  16      2       green    16 (2)    |
32      4       green    32 (4)    |  48      6       green    48 (6)
   1      0       green     1 (0)    |  17      2       green    17 (2)    |
33      4       green    33 (4)    |  49      6       green    49 (6)
   2      0       green     2 (0)    |  18      2       green    18 (2)    |
34      4       green    34 (4)    |  50      6       green    50 (6)
   3      0       green     3 (0)    |  19      2       green    19 (2)    |
35      4       green    35 (4)    |  51      6       green    51 (6)
   4      0       green     4 (0)    |  20      2       yellow   20 (2)    |
36      4       yellow   36 (4)    |  52      6       green    52 (6)
   5      0       green     5 (0)    |  21      2       green    21 (2)    |
37      4       green    37 (4)    |  53      6       green    53 (6)
   6      0       green     6 (0)    |  22      2       yellow   22 (2)    |
38      4       yellow   38 (4)    |  54      6       green    54 (6)
   7      0       green     7 (0)    |  23      2       green    23 (2)    |
39      4       green    39 (4)    |  55      6       green    55 (6)
   8      1       green     8 (1)    |  24      3       green    32 (4)    |
40      5       green    40 (5)    |  56      7       green    56 (7)
   9      1       green     9 (1)    |  25      3       green    25 (3)    |
41      5       green    41 (5)    |  57      7       green    57 (7)
  10      1       green    10 (1)    |  26      3       green    26 (3)    |
42      5       green    42 (5)    |  58      7       green    58 (7)
  11      1       green    11 (1)    |  27      3       green    27 (3)    |
43      5       green    43 (5)    |  59      7       green    59 (7)
  12      1       yellow   12 (1)    |  28      3       yellow   28 (3)    |
44      5       green    44 (5)    |  60      7       green    60 (7)
  13      1       green    13 (1)    |  29      3       green    29 (3)    |
45      5       green    45 (5)    |  61      7       green    61 (7)
  14      1       yellow   14 (1)    |  30      3       yellow   30 (3)    |
46      5       green    46 (5)    |  62      7       green    62 (7)
  15      1       green    15 (1)    |  31      3       green    31 (3)    |
47      5       green    47 (5)    |  63      7       green    63 (7)

PE1#
```

```
PE1#show qos-profile interface ce46/3
profile name: default
 profile type: dscp-to-queue (Ingress)
 mapping:
 -------+--------------------------- | -------+--------------------------- | -
------+--------------------------- | -------+---------------------------
```

```
  INPUT |         OUTPUT             |  INPUT |         OUTPUT             |
INPUT |         OUTPUT             |  INPUT |         OUTPUT
 -------+--------------------------- | -------+--------------------------- | -
------+--------------------------- | -------+---------------------------
  DSCP  |   TC  | Color  |remark DSCP|  DSCP  |   TC  | Color  |remark DSCP|
DSCP  |   TC  | Color  |remark DSCP|  DSCP  |   TC  | Color  |remark DSCP
       |       |        |   (TC)    |        |       |        |   (TC)    |
|       |       |        |   (TC)    |        |       |        |   (TC)
 -------+-------+--------+---------- | -------+-------+--------+---------- | -
------+-------+--------+---------- | -------+-------+--------+----------
   0      0       green     0 (0)    |  16      2       green    16 (2)    |
32      4       green    32 (4)    |  48      6       green    48 (6)
   1      0       green     1 (0)    |  17      2       green    17 (2)    |
33      4       green    33 (4)    |  49      6       green    49 (6)
   2      0       green     2 (0)    |  18      2       green    18 (2)    |
34      4       green    34 (4)    |  50      6       green    50 (6)
   3      0       green     3 (0)    |  19      2       green    19 (2)    |
35      4       green    35 (4)    |  51      6       green    51 (6)
   4      0       green     4 (0)    |  20      2       yellow   20 (2)    |
36      4       yellow   36 (4)    |  52      6       green    52 (6)
   5      0       green     5 (0)    |  21      2       green    21 (2)    |
37      4       green    37 (4)    |  53      6       green    53 (6)
   6      0       green     6 (0)    |  22      2       yellow   22 (2)    |
38      4       yellow   38 (4)    |  54      6       green    54 (6)
   7      0       green     7 (0)    |  23      2       green    23 (2)    |
39      4       green    39 (4)    |  55      6       green    55 (6)
   8      1       green     8 (1)    |  24      3       green    24 (3)    |
40      5       green    40 (5)    |  56      7       green    56 (7)
   9      1       green     9 (1)    |  25      3       green    25 (3)    |
41      5       green    41 (5)    |  57      7       green    57 (7)
  10      1       green    10 (1)    |  26      3       green    26 (3)    |
42      5       green    42 (5)    |  58      7       green    58 (7)
  11      1       green    11 (1)    |  27      3       green    27 (3)    |
43      5       green    43 (5)    |  59      7       green    59 (7)
  12      1       yellow   12 (1)    |  28      3       yellow   28 (3)    |
44      5       green    44 (5)    |  60      7       green    60 (7)
  13      1       green    13 (1)    |  29      3       green    29 (3)    |
45      5       green    45 (5)    |  61      7       green    61 (7)
  14      1       yellow   14 (1)    |  30      3       yellow   30 (3)    |
46      5       green    46 (5)    |  62      7       green    62 (7)
  15      1       green    15 (1)    |  31      3       green    31 (3)    |
47      5       green    47 (5)    |  63      7       green    63 (7)

profile name: default
 profile type: dscp-to-dscp (Egress)
 Status: Inactive
mapping:
 -----------------------+---------- | -----------------------+---------- | ---
--------------------+----------
        INPUT          |  OUTPUT   |        INPUT          |  OUTPUT   |
INPUT          |  OUTPUT
 -----------------------+---------- | -----------------------+---------- | ---
--------------------+----------
  Remark DSCP |  Color   | Out DSCP  |  Remark DSCP |  Color   | Out DSCP  |
Remark DSCP |  Color   | Out DSCP
      (TC)    |          |           |      (TC)    |          |           |
(TC)    |          |
 -------------+---------+---------- | -------------+---------+---------- | ---
----------+---------+----------
   0 (0)        green             0 |   0 (0)        yellow            0 |   0
(0)        red              0
```

```
   1 (0)         green           1 |    1 (0)          yellow          1 |    1
(0)     red          1
   2 (0)         green           2 |    2 (0)          yellow          2 |    2
(0)     red          2
   3 (0)         green           3 |    3 (0)          yellow          3 |    3
(0)     red          3
   4 (0)         green           4 |    4 (0)          yellow          4 |    4
(0)     red          4
   5 (0)         green           5 |    5 (0)          yellow          5 |    5
(0)     red          5
   6 (0)         green           6 |    6 (0)          yellow          6 |    6
(0)     red          6
   7 (0)         green           7 |    7 (0)          yellow          7 |    7
(0)     red          7
   8 (1)         green           8 |    8 (1)          yellow          8 |    8
(1)     red          8
   9 (1)         green           9 |    9 (1)          yellow          9 |    9
(1)     red          9
  10 (1)         green          10 |   10 (1)          yellow         12 |   10
(1)     red         14
  11 (1)         green          11 |   11 (1)          yellow         11 |   11
(1)     red         11
  12 (1)         green          12 |   12 (1)          yellow         12 |   12
(1)     red         14
  13 (1)         green          13 |   13 (1)          yellow         13 |   13
(1)     red         13
  14 (1)         green          14 |   14 (1)          yellow         14 |   14
(1)     red         14
  15 (1)         green          15 |   15 (1)          yellow         15 |   15
(1)     red         15
  16 (2)         green          16 |   16 (2)          yellow         16 |   16
(2)     red         16
  17 (2)         green          17 |   17 (2)          yellow         17 |   17
(2)     red         17
  18 (2)         green          18 |   18 (2)          yellow         20 |   18
(2)     red         22
  19 (2)         green          19 |   19 (2)          yellow         19 |   19
(2)     red         19
  20 (2)         green          20 |   20 (2)          yellow         20 |   20
(2)     red         22
  21 (2)         green          21 |   21 (2)          yellow         21 |   21
(2)     red         21
  22 (2)         green          22 |   22 (2)          yellow         22 |   22
(2)     red         22
  23 (2)         green          23 |   23 (2)          yellow         23 |   23
(2)     red         23
  24 (3)         green          24 |   24 (3)          yellow         24 |   24
(3)     red         24
  25 (3)         green          25 |   25 (3)          yellow         25 |   25
(3)     red         25
  26 (3)         green          26 |   26 (3)          yellow         28 |   26
(3)     red         30
  27 (3)         green          27 |   27 (3)          yellow         27 |   27
(3)     red         27
  28 (3)         green          28 |   28 (3)          yellow         28 |   28
(3)     red         30
  29 (3)         green          29 |   29 (3)          yellow         29 |   29
(3)     red         29
  30 (3)         green          30 |   30 (3)          yellow         30 |   30
(3)     red         30
  31 (3)         green          31 |   31 (3)          yellow         31 |   31
(3)     red         31
```

```
  32 (4)       green          32 |  32 (4)       yellow        32 |  32
(4)      red          32
  33 (4)       green          33 |  33 (4)       yellow        33 |  33
(4)      red          33
  34 (4)       green          34 |  34 (4)       yellow        36 |  34
(4)      red          38
  35 (4)       green          35 |  35 (4)       yellow        35 |  35
(4)      red          35
  36 (4)       green          36 |  36 (4)       yellow        36 |  36
(4)      red          38
  37 (4)       green          37 |  37 (4)       yellow        37 |  37
(4)      red          37
  38 (4)       green          38 |  38 (4)       yellow        38 |  38
(4)      red          38
  39 (4)       green          39 |  39 (4)       yellow        39 |  39
(4)      red          39
  40 (5)       green          40 |  40 (5)       yellow        40 |  40
(5)      red          40
  41 (5)       green          41 |  41 (5)       yellow        41 |  41
(5)      red          41
  42 (5)       green          42 |  42 (5)       yellow        42 |  42
(5)      red          42
  43 (5)       green          43 |  43 (5)       yellow        43 |  43
(5)      red          43
  44 (5)       green          44 |  44 (5)       yellow        44 |  44
(5)      red          44
  45 (5)       green          45 |  45 (5)       yellow        45 |  45
(5)      red          45
  46 (5)       green          46 |  46 (5)       yellow        46 |  46
(5)      red          46
  47 (5)       green          47 |  47 (5)       yellow        47 |  47
(5)      red          47
  48 (6)       green          48 |  48 (6)       yellow        48 |  48
(6)      red          48
  49 (6)       green          49 |  49 (6)       yellow        49 |  49
(6)      red          49
  50 (6)       green          50 |  50 (6)       yellow        50 |  50
(6)      red          50
  51 (6)       green          51 |  51 (6)       yellow        51 |  51
(6)      red          51
  52 (6)       green          52 |  52 (6)       yellow        52 |  52
(6)      red          52
  53 (6)       green          53 |  53 (6)       yellow        53 |  53
(6)      red          53
  54 (6)       green          54 |  54 (6)       yellow        54 |  54
(6)      red          54
  55 (6)       green          55 |  55 (6)       yellow        55 |  55
(6)      red          55
  56 (7)       green          56 |  56 (7)       yellow        56 |  56
(7)      red          56
  57 (7)       green          57 |  57 (7)       yellow        57 |  57
(7)      red          57
  58 (7)       green          58 |  58 (7)       yellow        58 |  58
(7)      red          58
  59 (7)       green          59 |  59 (7)       yellow        59 |  59
(7)      red          59
  60 (7)       green          60 |  60 (7)       yellow        60 |  60
(7)      red          60
  61 (7)       green          61 |  61 (7)       yellow        61 |  61
(7)      red          61
  62 (7)       green          62 |  62 (7)       yellow        62 |  62
(7)      red          62
```

```
  63 (7)        green            63 |  63 (7)        yellow           63 |  63
(7)        red              63

PE1#
```

CLI Commands

The Per-VRF DSCP preserve introduces the following configuration commands.

mpls lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when DSCP is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the `no` parameter with this to unconfigure DSCP preserve.

Note: In Qumran1 devices, DSCP preserve feature is not supported when the transport is Segment Routing.

Command Syntax

```
mpls lsp-encap-dscp-preserve (enable | disable)
no mpls lsp-encap-dscp-preserve
```

Parameters

`enable`	Enable the configuration.
`disable`	Disable the configuration

Default

disable

Command Mode

VRF mode

Applicability

Introduced in OcNOS version 6.5.3.

Example

Example for enabling or disabling DSCP preserve based on requirement per-vrf level:

```
#configure terminal
(config)#ip vrf vrf100
(config-vrf)#mpls lsp-encap-dscp-preserve (enable | disable)
(config-vrf)#commit
(config-vrf)#exit
```

Example for unconfiguring DSCP preserve:

```
#configure terminal
(config)#ip vrf vrf100
(config-vrf)#no mpls lsp-encap-dscp-preserve
(config-vrf)#commit
(config-vrf)#exit
```

mpls 6pe lsp-encap-dscp-preserve

Use this command to preserve DSCP for IP packets encapsulated into MPLS headers when DSCP is remarked on access interface. By default, DSCP is not preserved for IP packets encapsulated into MPLS headers.

Use the `no` parameter with this to unconfigure DSCP preserve.

Note: In Qumran1 devices, DSCP preserve feature is not supported when the transport is Segment Routing.

Command Syntax

```
mpls 6pe lsp-encap-dscp-preserve (enable | disable)
no mpls 6pe lsp-encap-dscp-preserve
```

Parameters

`enable`	Enable the configuration.
`disable`	Disable the configuration

Default

disable

Command Mode

Config mode

Applicability

Introduced in OcNOS version 6.5.3.

Example

Example for enabling or disabling DSCP preserve for 6PE services:

```
#configure terminal
(config)#mpls 6pe lsp-encap-dscp-preserve (enable | disable)
(config)#commit
(config)#exit
```

Example for unconfiguring DSCP preserve for 6PE services:

```
#configure terminal
(config)#no mpls 6pe lsp-encap-dscp-preserve
(config)#commit
(config)#exit
```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
DSCP	Differentiated Services Code Point (DSCP) is a 6-bit value used to classify the priority of Layer-3 packets upon entry into a network. DSCP values range from 0 to 63, 63 being the highest priority, 0 being best-effort traffic.
IS-IS	Intermediate System to Intermediate System (IS-IS) An Interior Gateway Protocol (IGP) that floods link state information throughout a network of routers. Each IS-IS router independently builds a database of the network's topology, aggregating the flooded network information. A Routing Information Base (RIB) is calculated from the database by constructing a shortest path tree (SPT).
MPLS	Multi-Protocol Label Switching (MPLS) A method for forwarding packets through a network. MPLS operates between the traditional definitions of Layer 2 (L2) and Layer 3 (L3).
QoS	Quality of Service (QoS) The ability to guarantee the delivery, control the bandwidth, set priorities for specific network traffic, and provide an appropriate level of security. QoS provides a level of predictability and control beyond the best effort delivery that a device provides by default.

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Label Distribution Protocol Configuration

CHAPTER 1 LDP Configuration

This chapter contains LDP (Label Distribution Protocol) configuration examples.

Label Distribution Protocol Overview

The Label Distribution Protocol (LDP) is a routing protocol used in MPLS technology. The LDP daemon (`ldpd`) uses NSM services to obtain routing information. Routers send Hello packets to establish Hello Adjacencies with other nearby routers. This opens the way for sessions between routers to be established during which routers exchange labels in preparation for forwarding packets.

LDP generates labels for and exchanges labels between peer routers. It works in with other routing protocols (RIP, OSPF and BGP) to create label-switched paths (LSP) used when forwarding packets. A label-switched path is the path taken by all packets that belong to the Forwarding Equivalence Class (FEC) corresponding to that LSP. This is analogous to establishing a virtual circuit in ATM (Asynchronous Transfer Mechanism). In this way, OcNOS LDP assigns labels to every destination address and destination prefix provided by OcNOS. The LDP interface to the MPLS forwarder adds labels to, and deletes labels from, the forwarding tables.

LDP Adjacencies

LDP defines a mechanism for discovering adjacent, LDP capable Label Switching Routers (LSR) that participate in label switching (adjacencies). Whenever a new router comes up it sends out a hello packet to a specified, multicast address announcing itself to the network. Every router directly connected to the network receives the packet. Receipt of a hello packet from another LSR creates a *Hello Adjacency* with that LSR. To create a Hello Adjacency with an LSR that cannot send/receive multicast packets, LDP allows a router to be manually configured to send unicast Hello packets to non-multicast LSRs . This non-multicast LSR is a *targeted peer*. Adjacencies are maintained by sending out periodic Hello packets to the multicast group and to all targeted peers. Hello packets are sent using UDP.

LDP Session

LDP capable LSRs establish a session before exchanging label information. All the session messages are sent using TCP to ensure reliable delivery. After the LSRs establish a session and negotiate options, a given pair of routers may exchange label information. The labels exchanged over a session are valid only during the lifetime of the session and routers release them when session is closed.

Forwarding Equivalence Class

A Forwarding Equivalence Class (FEC) section defines a set of packets that are forwarded on the same path by the MPLS network. Two common methods to define FEC are by advertising the IPv4 routes using:

- **Host Address** The LSR uses the address of the destination host to create this FEC. This means that all the packets going to this destination will take the same LSP.
- **Prefix** The LSR uses destination prefix to create this FEC. This means that all the packets take the LSP corresponding to the longest matching prefix.

Label Generation

An LDP Label is a 20-bit number the LSR uses to forward a packet to its destination. When an LSR creates a new FEC, the router generates new labels and distributes them to its peers. A router keeps both incoming and outgoing labels in its database.

Label Distribution Modes

The OcNOS LDP implementation supports two label distribution modes:

- **Downstream Unsolicited** In this mode, next hop LSRs distribute labels to peers without waiting for a label request.
- **Downstream on Demand** In this mode, a LSR distributes a label to a peer only if there is a pending label request from the peer.

Label Retention Mode

The OcNOS LDP implementation supports two label retention modes:

- **Liberal Retention Mode** In this mode, the LSR retains all labels received from all sources. This mode helps in fast LSP setup in case of a change in next hop.
- **Conservative Retention Mode** In this mode, the LSR retains only those labels received from peers that are the next hop for a given FEC. This mode is used by LSRs that have a constraint on the number of labels that it can retain at any given time.

LSP Control

LSPs can be set up in the following two ways:

- **Ordered Control** In this mode, an LSR distributes a label for a FEC to its peer only if it has a corresponding label from its next hop or it is the egress node.
- **Independent Control** In this mode, an LSR may distribute a label to its peers without waiting for a corresponding label from its next hop.

Loop Detection

Loop detection can be enabled to detect routing loops in LSPs. There are two methods supported for the loop detection mechanism:

- **Hop Count** During setup of an LSP, the LSP passes hop count with the LSP setup messages. This hop count is incriminated by each node router participating in LSP establishment. If the hop count exceeds the maximum configured value, the LSP setup process is stopped and a notification message is passed back to the message originator.
- **Path Vector** A path vector contains a list of LSR identifiers. This is passed as a part of LSP setup messages. Each LSR participating in the LSP establishment adds its own LSR identifier to the path vector. If an LSR finds its own identifier in the path vector, it drops the message and sends a message back to the originator.

The use of these messages ensures that a loop is detected while establishing a label switched path and before any data is passed over that LSP.

Configure LDP

The `enable-ldp ipv4` command is used to enable LDP for IPv4 on a specified interface, as follows:

- `enable-ldp ipv4` enables only IPv4 on the interface

For the examples covered in this section, the command `enable-ldp ipv4` is used.

Enable Label Switching

Running LDP on a system requires the following tasks:

1. Enabling label-switching on the interface on NSM.
2. Enabling LDP on an interface in the LDP daemon.
3. Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
4. Configuring the transport address.

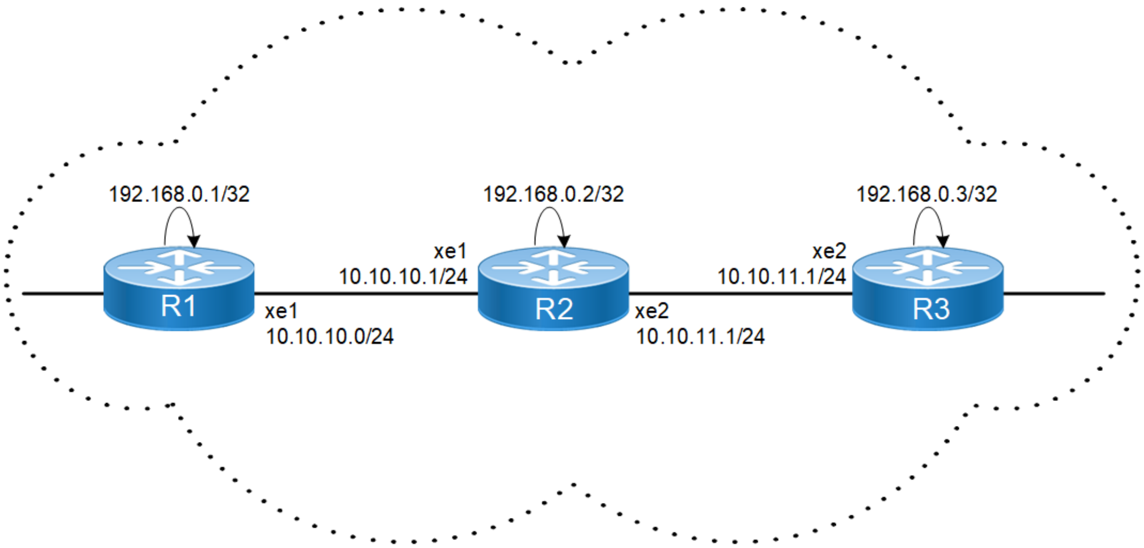

Figure 1-32: Basic LDP Topology

R1 - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 10.10.10.1/24`	Assign IP address to interface.
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback (`lo`) interface to be configured.
`(config-if)#ip address 192.168.0.1/32 secondary`	Set the IP address of the loopback interface to `192.168.0.1/32`.
`(config-if)#commit`	Commit the transaction.

R1 - LDP

`(config)#router ldp`	Enter `Router` mode for LDP.
`(config-router)#router-id 192.168.0.1`	Set the router ID to IP address `192.168.0.1`.

`(config-router)#transport-address ipv4 192.168.0.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. **Note**: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`(config-router)#targeted-peer ipv4 192.168.0.3`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode.
`(config-router)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on `xe1`.
`(config-if)#commit`	Commit the transaction.

R1 - OSPF

`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 10.10.10.0/24 area 0` `(config-router)#network 192.168.0.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID `(0)` with the interface.
`(config-router)#commit`	Commit the transaction.

R2 - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Specify the loopback (`lo`) interface to be configured.
`(config-if)#ip address 192.168.0.2/32 secondary`	Set the IP address of the loopback interface to `192.168.0.2/32`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 10.10.10.2/24`	Assign IP address to interface
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Specify the interface `(xe2)` to be configured.
`(config-if)#ip address 10.10.11.1/24`	Assign IP address to interface.
`(config-if)#label-switching`	Enable label switching on interface `xe2`.
`(config-if)#commit`	Commit the transaction.

R2 - LDP

`(config)#router ldp`	Enter `Router` mode.
`(config-router)#router-id 192.168.0.2`	Set the router ID to IP address `192.168.0.2`.

(config-router)#transport-address ipv4 192.168.0.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. **Note**: It is preferable to use the loopback address as transport address. In addition, use the parameter “ipv6” if you are configuring an IPv6 interface.
(config-router)#exit	Exit `Router` mode and return to `Configure` mode.
(config)#interface xe1	Specify the interface `(xe1)` to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (`xe1`).
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface `(xe2)` to be configured.
(config-if)#enable-ldp ipv4	Enable LDP on a specified interface (`xe`.
(config-if)#commit	Commit the transaction.

R2 - OSPF

(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#network 10.10.10.0/24 area 0 (config-router)#network 10.10.11.0/24 area 0 (config-router)#network 192.168.0.2/32 area 0	Define the interfaces on which OSPF runs and associate the area ID `(0)` with them.
(config-router)#commit	Commit the transaction.

R3 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Specify the loopback (`lo`) interface to be configured.
(config-if)#ip address 192.168.0.3/32 secondary	Set the IP address of the loopback interface to `192.168.0.3/32`.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface `(xe2)` to be configured.
(config-if)#ip address 10.10.11.1/24	Set the IP address of the interface to `10.10.11.1/24`.
(config-if)#label-switching	Enable label switching on interface `xe2`.
(config-if)#commit	Commit the transaction.

R3 - LDP

(config)#router ldp	Enter `Router` mode.
(config-router)#router-id 192.168.0.3	Set the router ID for IP address `192.168.0.3`.
(config-router)#transport-address ipv4 192.168.0.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. **Note**: It is preferable to use the loopback address as transport address. In addition, use the parameter “ipv6” if you are configuring an IPv6 interface.

`(config-router)#targeted-peer ipv4 192.168.0.1`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode.
`(config-router)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on `xe2`.
`(config-if)#commit`	Commit the transaction.

R3 - OSPF

`(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#network 10.10.11.0/24 area 0` `(config-router)#network 192.168.0.3/32 area 0`	Define the interfaces on which OSPF runs and associate the area ID `(0)` with them.
`(config-router)#commit`	Commit the transaction.

Validation

PE1

```
PE1#show ldp session
Peer IP Address    IF Name  My Role  State          KeepAlive    UpTime
192.168.0.2        xe1      Passive  OPERATIONAL    30           00:18:59
192.168.0.3        xe1      Passive  OPERATIONAL    30           00:02:07

PE1#show ldp targeted-peer count
Num Targeted Peers: 1   [UP: 1]

PE1#show ldp session count
Multicast Peers  : 2   [UP: 1]
Targeted Peers   : 1   [UP: 0]
Total Sessions   : 2   [UP: 1]

PE1#show ldp routes
Prefix Addr   Nexthop Addr  Intf   Owner
10.10.10.0/24   0.0.0.0   xe1
10.10.11.0/24  10.10.10.2  xe1
192.168.0.1/32  0.0.0.0   lo
192.168.0.2/32  10.10.10.2  xe1
192.168.0.3/32  10.10.10.2  xe1

PE1#show ldp fec-ipv4 count
Num. IPv4 FEC(s): 5
```

P

```
P#show ldp session
```

```
Peer IP Address    IF Name  My Role  State        KeepAlive   UpTime
192.168.0.1        xe1      Active   OPERATIONAL   30         00:23:52
192.168.0.3        xe2      Passive  OPERATIONAL   30         00:23:49

P#show ldp session count
 Multicast Peers  : 3   [UP: 2]
 Targeted Peers  : 0   [UP: 0]
 Total Sessions  : 2   [UP: 2]

P#show ldp routes
Prefix Addr   Nexthop Addr  Intf  Owner
10.10.10.0/24   0.0.0.0     xe1   connected
10.10.11.0/24   0.0.0.0     xe2   connected
192.168.0.1/32  10.10.10.1  xe1   ospf
192.168.0.2/32  0.0.0.0     lo    connected
192.168.0.3/32  10.10.11.2  xe2   ospf
```

PE2

```
PE2#show ldp session
Peer IP Address    IF Name  My Role  State          KeepAlive   UpTime
192.168.0.2        xe2      Active   OPERATIONAL     30         00:27:47
192.168.0.1        xe2      Active   OPERATIONAL     30         00:10:58

PE2#show ldp session count
 Multicast Peers  : 2   [UP: 1] Targeted Peers   : 1   [UP: 1]
 Total Sessions  : 2   [UP: 2]

OcNOS#show ldp targeted-peer count
Num Targeted Peers: 1   [UP: 1]

OcNOS#show ldp routes
Prefix Addr   Nexthop Addr  Intf   Owner
10.10.10.0/24   10.10.11.1   xe2   ospf
10.10.11.0/24   0.0.0.0      xe2   connected
192.168.0.1/32  10.10.11.1   xe17  ospf
192.168.0.2/32  10.10.11.1   xe2   ospf
192.168.0.3/32  0.0.0.0      lo    connected

PE2#show ldp fec
fec  fec-ipv4

PE2#show ldp fec-ipv4 count
------------------------
Num. IPv4 FEC(s): 5
------------------------
```

LDP MD5 Authentication

LDP MD5 configuration enables LDP MD5 password authentication on a per-peer basis.

Direct LDP Session

In this example, MD5 authentication is configured for a direct LDP session.

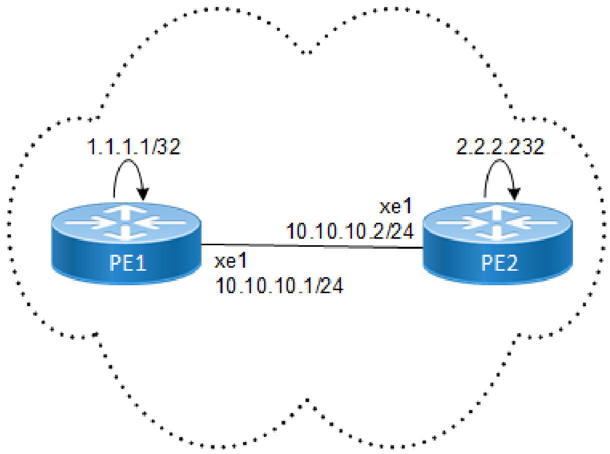

Figure 1-33: Topology for Direct Session MD5

R1

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter `Router` mode.
`(config)#router-id 1.1.1.1`	Configure the router id.
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
`(config-router)#neighbor 10.10.10.2 auth md5 password 0 pwd1`	Configure the MD5 authentication and password, `pwd1`, for the neighbor, `10.10.10.2`.
`(config-router)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to `1.1.1.1/32`.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 10.10.10.1/24`	Set the IP address of the interface to `10.10.10.1/24..`
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `xe1`.
`(config-if)#commit`	Commit the transaction.

R2

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter `Router` mode.
`(config)#router-id 2.2.2.2`	Configure the router id.
`(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.

`(config-router)#neighbor 10.10.10.1 auth md5 password 0 pwd1`	Configure the MD5 authentication and password, `pwd1`, for the neighbor, `10.10.10.1`.
`(config-router)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to `2.2.2.2/32`.
`(config)#interface xe1`	Specify the interface `(xe1)` to be configured.
`(config-if)#ip address 10.10.10.2/24`	Set the IP address of the interface to `10.10.10.2/24`.
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `xe1`.
`(config-if)#commit`	Commit the transaction.

Validation

PE1

```
PE1#show ldp session
Peer IP Address          IF Name    My Role    State          KeepAlive  UpTime
2.2.2.2                  xe1        Passive    OPERATIONAL    30         00:14:53

PE1#show ldp session count
--------------------------------------------
 Multicast Peers      : 1         [UP: 1]
 Targeted Peers       : 1         [UP: 1]
 Total Sessions       : 1         [UP: 1]
```

PE2

```
PE2#show ldp session
Peer IP Address          IF Name    My Role    State         KeepAlive  UpTime
1.1.1.1                  xe1        Active    OPERATIONAL    30         00:15:05

PE2#sh ldp session count
--------------------------------------------
 Multicast Peers      : 1         [UP: 1]
 Targeted Peers       : 1         [UP: 1]
 Total Sessions       : 1         [UP: 1]
--------------------------------------------
```

Configure LDP MD5 for Targeted LDP Session

In this example, MD5 authentication is configured for the targeted LDP session established between R1 and R3.

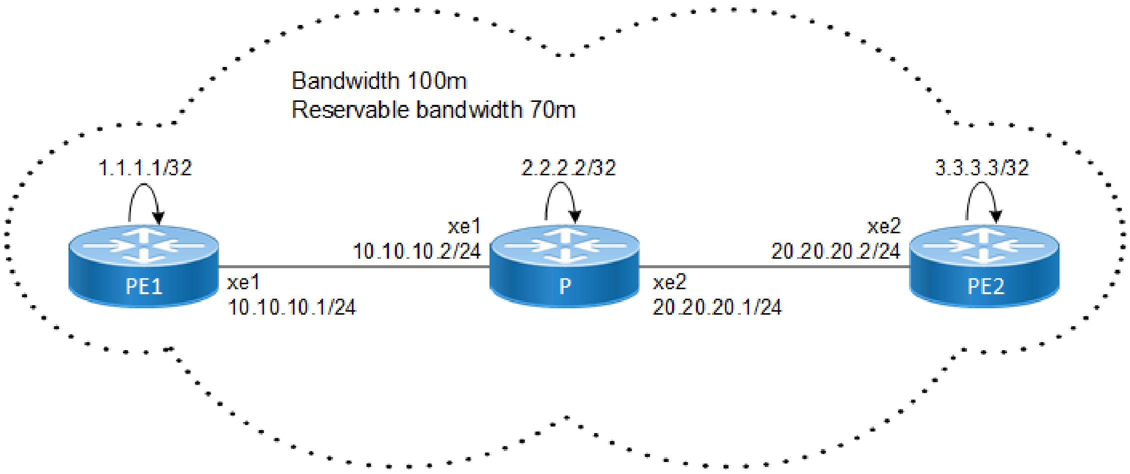

Figure 1-34: Topology for Targeted Session MD5

PE1

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter `Router` mode.
`(config-router)#neighbor 10.10.10.2 auth md5 password 0 pwd1`	Configure the MD5 authentication and password, `pwd1`, for the neighbor, `10.10.10.2`.
`(config-router)#targeted-peer ipv4 3.3.3.3`	Configure the targeted peer IP address (R3 loopback address).
`(config-router-targeted-peer)#exit`	Exit targeted peer mode.
`(config-router)#neighbor 3.3.3.3 auth md5 password 0 pwd2`	Configure the MD5 authentication and password, `pwd2`, for the targeted peer, `3.3.3.3`.
`(config-router)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface lo`	Specify the loopback interface `(lo)` to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to 1.1.1.1/ 32.
`(config-if)#commit`	Commit the transaction.
`(config)#interface xe1`	Specify the interface (xe1) to be configured.
`(config-if)#ip address 10.10.10.1/24`	Set the IP address of the interface to 10.10.10.1/24.
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `xe1`.

P

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter `Router` mode to enable LDP.
`(config)#router-id 2.2.2.2`	Configure the router ID.
`(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface.
`(config-router)#exit`	Exit the `Router` mode and return to the `Configure` mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.

(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the interface (xe1) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enter Router mode.
(config-router)#router-id 3.3.3.3	Configure the router-id
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure the targeted peer IP address (R1 loopback address).
(config-router-targeted-peer)#exit	Exit targeted peer mode.
(config-router)#neighbor 1.1.1.1 auth md5 password 0 pwd2	Configure the MD5 authentication and password, pwd2, for the targeted peer, 1.1.1.1.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface lo	Specify the loopback (lo) interface to be config.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Specify the interface (xe2) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP on interface xe2.
(config-if)#commit	Commit the transaction.

Removing MD5 Authentication for LDP Session

This example shows removing the MD5 authentication configuration from an LDP session.

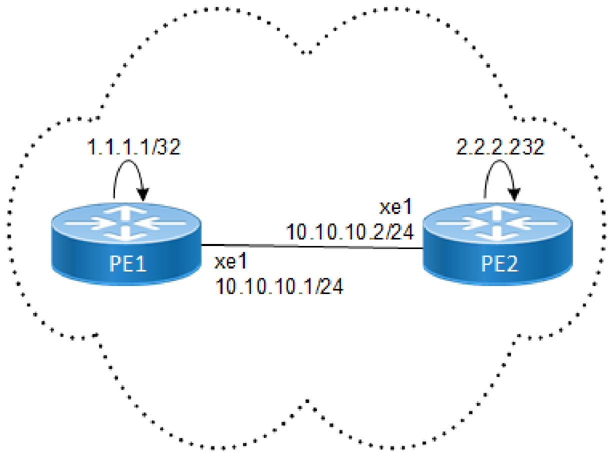

Figure 1-35: LDP Session Topology

PE1

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter `Router` mode.
`(config-router)#no neighbor 10.10.10.2 auth md5 password`	Remove MD5 authentication for the neighbor, `10.10.10.2`.
`(config-router)#commit`	Commit the transaction.

PE2

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enter `Router` mode.
`(config-router)#no neighbor 10.10.10.1 auth md5 password`	Remove MD5 authentication for the neighbor, `10.10.10.1`.
`(config-router)#commit`	Commit the transaction.
`(config)#interface lo`	Specify the loopback (lo) interface to be config
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to `2.2.2.2/32`
`(config-if)#exit`	Exit lo interface
`(config-if)#interface xe1`	Specify the interface (`xe1`) to be configured.
`(config-if)#ip address 10.10.10.2/24`	Set the IP address of the interface to `10.10.10.2/24`
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#enable-ldp ipv4`	Enable LDP on interface `xe1`.
`(config-if)#commit`	Commit the transaction.

Validation for LDP Session Count

This example shows the number of configured LDP basic neighbors and targeted neighbors count.

```
#show ldp session count
--------------------------------------------
Basic sessions      : 100          [UP: 100]
```

```
 Targeted sessions   : 500          [UP: 500]
 Total Sessions      : 600          [UP: 600]
 --------------------------------------------
 #show ldp targeted-peer count
 -------------------------------------------------
 Num Targeted Peers: 500          [UP: 500]
 -------------------------------------------------
```

Validation for FTN, SWAP, and POP Entries

This example shows forwarding table entries, SWAP entries and POP entries for IPV4 and IPV6 prefixes.

```
#show mpls forwarding-table count
---------------------------------------------
  Num FTNs       : 300000          [UP: 3, INSTALLED: 300000]
  Primary FTNs   : 300000          [UP: 3, INSTALLED: 300000]
  Secondary FTNs : 0               [UP: 0, INSTALLED: 0]
---------------------------------------------
---------------------------------------------
  Num IPV6 FTNs       : 300000          [UP: 300000, INSTALLED: 300000]
  Primary IPV6 FTNs   : 300000          [UP: 300000, INSTALLED: 300000]
  Secondary IPV6 FTNs : 0               [UP: 0, INSTALLED: 0]
---------------------------------------------

#show mpls ilm-table count
------------------------------------------------
Num ILMs         : 300000          [UP: 0, INSTALL: 300000]
  Swap Entries   : 300000          [UP: 0, INSTALL: 300000]
  Pop Entries    : 0               [UP: 0, INSTALL: 0]
  VC Pop Entries : 0               [UP: 0]
------------------------------------------------
```

MPLS LDP PING and TRACEROUTE

This example shows MPLS ping and trace route for LDP

```
#show ip ospf neighbor
Total number of full neighbors: 1
OSPF process 0 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2         1   Full/DR          00:00:33    10.10.10.2     xe1
0

#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive
2.2.2.2                   xe1       Passive   OPERATIONAL   30

#show mpls  forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
```

```
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -           -     LSP_DEFAULT  3
xe1        No    10.10.10.2

#ping mpls ldp 2.2.2.2/32 detail
Sending 5 MPLS Echos to 2.2.2.2, timeout is 5 seconds
Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
Type 'Ctrl+C' to abort
! seq_num = 1 2.2.2.2 1.73 ms
! seq_num = 2 2.2.2.2 1.46 ms
! seq_num = 3 2.2.2.2 0.64 ms
! seq_num = 4 2.2.2.20.65 ms
! seq_num = 5 2.2.2.20.62 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.62/1.18/1.73

#trace mpls ldp 2.2.2.2/32 detail
Tracing MPLS Label Switched Path to 2.2.2.2, timeout is 5 seconds
Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
Type 'Ctrl+C' to abort
0 10.10.10.2 [Labels: 0]
! 1 2.2.2.2 0.69 ms

#ping mpls ldp 2.2.2.2/32 detail interval 5000 rep
reply-mode repeat
#ping mpls ldp 2.2.2.2/32 detail interval 5000 repeat 50
Sending 50 MPLS Echos to 2.2.2.2, timeout is 5 seconds
Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
```

```
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
Type 'Ctrl+C' to abort
! seq_num = 1 2.2.2.2 0.70 ms
! seq_num = 2 2.2.2.2 0.73 ms
! seq_num = 3 2.2.2.2 0.71 ms
Success Rate is 100.00 percent (3/3)
round-trip min/avg/max = 0.70/0.71/0.73
```

LDP Session Protection

LDP Session Protection is an optimization feature. It is used when directly connected LDP peer sessions (via multicast) become unavailable but still have IP reachability over a different path. LDP bindings are kept in the LIB to save time from full synchronization when the direct connections comes back up.

There are two types of LDP connections:

- Direct LDP Session - directly connected LSR, one hop away.
- Targeted LDP Session - not directly connected LSR, multiple hops away.

By default if the directly connected LDP session loses connectivity to its peer, all bindings are flushed from the LIB. When interfaces come up and LDP sessions are re-established, LDP has to synchronize its label bindings.

Enable session protection for indirect link failures to protect the labels until the session is active when multicast adjacency gets deleted. When multicast and TLDP connection exists between the same peer, the interface down notification is received only on the router with the link failure but not in the peer. When the interface goes down the multicast adjacency and the labels get deleted without notifying the peer device. When the interface comes up before the adjacency hold timer expires in the peer node, multicast adjacency is added and advertises the labels to the peer but does not receive any labels from the peer as there is no change in the adjacency.

LDP Session Protection is an optimization, when enabled, will not flush the LIB when direct LDP sessions go down. As long as there exists another path to the LDP Peer, it will maintain the LIB synchronized using Targeted LDP Session. IGP will cause a reroute, but the label bindings will still be present from the old peer. When interfaces come back up, LDP will not need to synchronize since it maintains the state using the targeted sessions.

1. Running LDP Session Protection on a system requires the following tasks:
2. Enabling label-switching on the interface on NSM.
3. Enabling LDP on an interface in the LDP daemon.
4. Running an IGP (Internal Gateway Protocol), for example, OSPF, to distribute reachability information within the MPLS cloud.
5. Configuring the transport address.
6. Configuring LDP Session Protection.

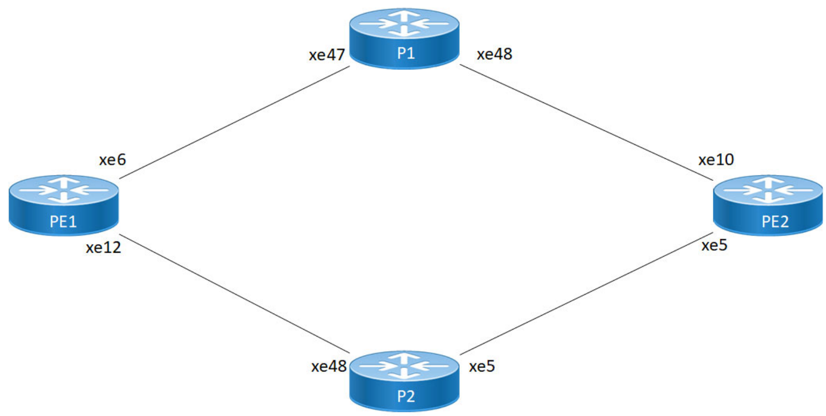

Figure 1-36: Basic LDP Topology

PE1 - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface xe6`	Specify the interface (xe6) to be configured.
`(config-if)#ip address 10.10.10.1/24`	Configure IPv4 address for xe6
`(config-if)#label-switching`	Enable label switching on interface xe6.
`(config)#interface xe12`	Specify the interface (xe12) to be configured.
`(config-if)#ip address 30.30.30.1/24`	Configure IPv4 address for xe12
`(config-if)#label-switching`	Enable label switching on interface xe12.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32`	Set the IP address of the loopback interface to 1.1.1.1/32.
`(config-if)#commit`	Commit the transaction.

PE1 - LDP

`(config)#router ldp`	Enter Router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
`(config-router)#exit`	Exit the Router mode and return to the Configure mode.
`(config)#interface xe6`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on xe6.
`(config)#interface xe12`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP on xe12.
`(config-if)#commit`	Commit the transaction.

PE1 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 1.1.1.1	Configure Router ID
(config-router)#network 1.1.1.1/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.10.10.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 30.30.30.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

P1 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe47	Specify the interface (xe47) to be configured.
(config-if)#ip address 10.10.10.2/24	Configure IPv4 address for xe47
(config-if)#label-switching	Enable label switching on interface xe47.
(config)#interface xe48	Specify the interface (xe48) to be configured.
(config-if)#ip address 20.20.20.1/24	Configure IPv4 address for xe48
(config-if)#label-switching	Enable label switching on interface xe48.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#commit	Commit the transaction.

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P1 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe47	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe47.
(config)#interface xe48	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe48.
(config-if)#commit	Commit the transaction.

P1 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 2.2.2.2	Configure Router ID
(config-router)#network 2.2.2.2/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.10.10.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.20.20.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

P2 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe48	Specify the interface (xe48) to be configured.
(config-if)#ip address 30.30.30.2/24	Configure IPv4 address for xe48
(config-if)#label-switching	Enable label switching on interface xe48.
(config)#interface xe5	Specify the interface (xe5) to be configured.
(config-if)#ip address 40.40.40.1/24	Configure IPv4 address for xe5
(config-if)#label-switching	Enable label switching on interface xe5.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 4.4.4.4/32 secondary	Set the IP address of the loopback interface to 4.4.4.4/32.
(config-if)#commit	Commit the transaction.

P2 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 4.4.4.4	Set the router ID to IP address 4.4.4.4
(config-router)#transport-address ipv4 4.4.4.4	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe48	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe48.
(config)#interface xe5	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe5.
(config-if)#commit	Commit the transaction.

P2 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 4.4.4.4	Configure Router ID
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.20.20.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 30.30.30.1/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

PE2 - NSM

#configure terminal	Enter configure mode.
(config)#interface xe10	Specify the interface (xe10) to be configured.
(config-if)#ip address 20.20.20.2/24	Configure IPv4 address for xe10
(config-if)#label-switching	Enable label switching on interface xe10.
(config)#interface xe5	Specify the interface (xe5) to be configured.
(config-if)#ip address 40.40.40.2/24	Configure IPv4 address for xe5
(config-if)#label-switching	Enable label switching on interface xe5.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
(config-if)#commit	Commit the transaction.

PE2 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 3.3.3.3	Set the router ID to IP address 3.3.3.3
(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter "ipv6" if you are configuring an IPv6 interface.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe10	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe10.
(config)#interface xe5	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe5.
(config-if)#commit	Commit the transaction.

PE2 - OSPF

(config)#router ospf 1	Configure the routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 3.3.3.3	Configure Router ID
(config-router)#network 3.3.3.3/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 20.20.20.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 40.40.40.2/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.

Validation

Without session protection enabled

Verify that session protection status is not shown when session protection not enabled.

```
PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
C            1.1.1.1/32 is directly connected, lo, 00:04:22
```

```
O            2.2.2.2/32 [110/2] via 10.10.10.2, xe12, 00:03:03
O            3.3.3.3/32 [110/3] via 10.10.10.2, xe12, 00:02:49
O            4.4.4.4/32 [110/31] via 30.30.30.2, xe6, 00:02:17
C            10.10.10.0/24 is directly connected, xe12, 00:03:48
O            20.20.20.0/24 [110/2] via 10.10.10.2, xe12, 00:03:03
C            30.30.30.0/24 is directly connected, xe6, 00:03:02
O            40.40.40.0/24 [110/31] via 30.30.30.2, xe6, 00:02:17
C            127.0.0.0/8 is directly connected, lo, 00:04:22

Gateway of last resort is not set

PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
4.4.4.4                   xe6        Passive   OPERATIONAL   30    00:02:25
2.2.2.2                   xe12       Passive   OPERATIONAL   30    00:03:11
PE1#show ldp targeted-peers
PE1#show ldp session 2.2.2.2
Session state          : OPERATIONAL
Session role           : Passive
TCP Connection         : Established
IP Address for TCP     : 2.2.2.2
Interface being used   : xe12
Peer LDP ID            : 2.2.2.2:0
Peer LDP Password      : Not Set
Adjacencies            : 10.10.10.2
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart       : Not Capable
Keepalive Timeout      : 30
Reconnect Interval     : 15
Address List received : 2.2.2.2
                        10.10.10.2
                        20.20.20.1
                        254.128.0.0
Received Labels :       Fec                Label           Maps To
                IPV4:3.3.3.3/32        52480           24963
                IPV4:20.20.20.0/24     impl-null       24964
                IPV4:10.10.10.0/24     impl-null       none
                IPV4:2.2.2.2/32        impl-null       24962
Sent Labels :   Fec                    Label           Maps To
                IPV4:40.40.40.0/24     24961           impl-null
                IPV4:4.4.4.4/32        24960           impl-null
                IPV4:30.30.30.0/24     impl-null       none
                IPV4:10.10.10.0/24     impl-null       none
                IPV4:1.1.1.1/32        impl-null       none
PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

```
(m) - FTN mapped over multipath transport

Code    FEC                FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         2         -          Yes   LSP_DEFAULT  3
xe12         No    10.10.10.2
   L>   3.3.3.3/32         3         5         -          Yes   LSP_DEFAULT  52480
xe12         No    10.10.10.2
   L>   4.4.4.4/32         4         7         -          Yes   LSP_DEFAULT  3
xe6          No    30.30.30.2
   L>   20.20.20.0/24      2         3         -          Yes   LSP_DEFAULT  3
xe12         No    10.10.10.2
   L>   40.40.40.0/24      5         8         -          Yes   LSP_DEFAULT  3
xe6          No    30.30.30.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe12, out label: 52480
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
        Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3
     Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
      Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
       Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
     Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                    LSP-Type
   L>   3.3.3.3/32         4          24963       52480       N/A        xe12
10.10.10.2                 LSP_DEFAULT
   L>   40.40.40.0/24      2          24961       3           N/A        xe6
30.30.30.2                 LSP_DEFAULT
   L>   4.4.4.4/32         1          24960       3           N/A        xe6
30.30.30.2                 LSP_DEFAULT
   L>   2.2.2.2/32         3          24962       3           N/A        xe12
10.10.10.2                 LSP_DEFAULT
   L>   20.20.20.0/24      5          24964       3           N/A        xe12
10.10.10.2                 LSP_DEFAULT

PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                   Code    Session             Out Label    ELC   Nexthop Addr
1.1.1.1/32            E >     non-existent        none         No    connected
2.2.2.2/32            NL>     2.2.2.2             impl-null    No    10.10.10.2
3.3.3.3/32            NL      4.4.4.4             24325        No    no nexthop
                      NL>     2.2.2.2             52480        No    10.10.10.2
4.4.4.4/32            NL>     4.4.4.4             impl-null    No    30.30.30.2
10.10.10.0/24         NL      2.2.2.2             impl-null    No    connected
                      E >     non-existent        none         No    connected
20.20.20.0/24         NL      4.4.4.4             24326        No    no nexthop
                      NL>     2.2.2.2             impl-null    No    10.10.10.2
30.30.30.0/24         NL      4.4.4.4             impl-null    No    connected
                      E >     non-existent        none         No    connected
```

```
40.40.40.0/24       NL>     4.4.4.4             impl-null   No    30.30.30.2
```

Configure Session Protection:

Note: Recommended to configure both ends.

Configure session protection under LDP in both nodes.

PE1

(config)#router ldp	Enter Router mode for LDP.
(config-router)#session-protection	Session-protection protect label indefinitely if no timer mentioned.
(config-router)#commit	Commit and exit

P1

(config)#router ldp	Enter Router mode for LDP.
(config-router)#session-protection	Session-protection protect label indefinitely if no timer mentioned.
(config-router)#commit	Commit and exit

Validation

With session protection command enabled

Verify that session protection status shown once session protection enabled in both peer nodes.

```
PE1#show ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
4.4.4.4                   xe6        Passive   OPERATIONAL   30    00:05:46
2.2.2.2                   xe12       Passive   OPERATIONAL   30    00:06:32
PE1#show ldp targeted-peers
IP Address          Interface
2.2.2.2             xe12
4.4.4.4             xe6
PE1#show ldp session 2.2.2.2
Session state          : OPERATIONAL
Session role           : Passive
TCP Connection         : Established
IP Address for TCP     : 2.2.2.2
Interface being used   : xe12
Peer LDP ID            : 2.2.2.2:0
Peer LDP Password      : Not Set
Adjacencies            : 10.10.10.2
                         2.2.2.2
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart       : Not Capable
```

```
Keepalive Timeout     : 30
Reconnect Interval    : 15
Session protection    : Ready
Address List received : 2.2.2.2
                        10.10.10.2
                        20.20.20.1
                        254.128.0.0
Received Labels :       Fec               Label           Maps To
                IPV4:3.3.3.3/32         52480           24963
                IPV4:20.20.20.0/24      impl-null       24964
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:2.2.2.2/32         impl-null       24962
Sent Labels :   Fec                     Label           Maps To
                IPV4:40.40.40.0/24      24961           impl-null
                IPV4:4.4.4.4/32         24960           impl-null
                IPV4:30.30.30.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:1.1.1.1/32         impl-null       none
PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          1         2         -          Yes   LSP_DEFAULT  3
xe12        No    10.10.10.2
   L>   3.3.3.3/32          3         5         -          Yes   LSP_DEFAULT  52480
xe12        No    10.10.10.2
   L>   4.4.4.4/32          4         7         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   20.20.20.0/24       2         3         -          Yes   LSP_DEFAULT  3
xe12        No    10.10.10.2
   L>   40.40.40.0/24       5         8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                    LSP-Type
   L>   3.3.3.3/32         4          24963       52480       N/A        xe12
10.10.10.2                 LSP_DEFAULT
   L>   40.40.40.0/24      2          24961       3           N/A        xe6
30.30.30.2                 LSP_DEFAULT
   L>   4.4.4.4/32         1          24960       3           N/A        xe6
30.30.30.2                 LSP_DEFAULT
```

```
   L>   2.2.2.2/32        3           24962      3          N/A        xe12
10.10.10.2                LSP_DEFAULT
   L>   20.20.20.0/24     5           24964      3          N/A        xe12
10.10.10.2                LSP_DEFAULT
PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe12, out label: 52480
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe12, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
```

```
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          E >     non-existent        none        No    connected
2.2.2.2/32          NL>     2.2.2.2             impl-null   No    10.10.10.2
3.3.3.3/32          NL      4.4.4.4             24325       No    no nexthop
                    NL>     2.2.2.2             52480       No    10.10.10.2
4.4.4.4/32          NL>     4.4.4.4             impl-null   No    30.30.30.2
10.10.10.0/24       NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL      4.4.4.4             24326       No    no nexthop
                    NL>     2.2.2.2             impl-null   No    10.10.10.2
30.30.30.0/24       NL      4.4.4.4             impl-null   No    connected
                    E >     non-existent        none        No    connected
40.40.40.0/24       NL>     4.4.4.4             impl-null   No    30.30.30.2


P1#show ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
3.3.3.3                   xe5        Passive   OPERATIONAL   30    00:05:40
1.1.1.1                   xe48       Active    OPERATIONAL   30    00:06:43
P1#show ldp targeted-peers
IP Address          Interface
1.1.1.1             xe48
3.3.3.3             xe5

P1#show ldp session 1.1.1.1
Session state          : OPERATIONAL
Session role           : Active
TCP Connection         : Established
IP Address for TCP     : 1.1.1.1
Interface being used   : xe48
Peer LDP ID            : 1.1.1.1:0
Peer LDP Password      : Not Set
Adjacencies            : 10.10.10.1
                         1.1.1.1
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart       : Not Capable
Keepalive Timeout      : 30
Reconnect Interval     : 15
Session protection     : Ready
Address List received : 1.1.1.1
```

```
                        10.10.10.1
                        30.30.30.1
                        254.128.0.0
Received Labels :       Fec               Label           Maps To
                IPV4:4.4.4.4/32        24960           52482
                IPV4:40.40.40.0/24     24961           52484
                IPV4:30.30.30.0/24     impl-null       52483
                IPV4:10.10.10.0/24     impl-null       none
                IPV4:1.1.1.1/32        impl-null       52481
Sent Labels :   Fec                    Label           Maps To
                IPV4:3.3.3.3/32        52480           impl-null
                IPV4:20.20.20.0/24     impl-null       none
                IPV4:10.10.10.0/24     impl-null       none
                IPV4:2.2.2.2/32        impl-null       none

P1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         1         2         -           Yes   LSP_DEFAULT  3
xe48        No    10.10.10.1
   L>   3.3.3.3/32         5         9         -           Yes   LSP_DEFAULT  3
xe5         No    20.20.20.2
   L>   4.4.4.4/32         3         5         -           Yes   LSP_DEFAULT  24960
xe48        No    10.10.10.1
   L>   30.30.30.0/24      2         3         -           Yes   LSP_DEFAULT  3
xe48        No    10.10.10.1
   L>   40.40.40.0/24      4         7         -           Yes   LSP_DEFAULT  24961
xe48        No    10.10.10.1


P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                   LSP-Type
   L>   30.30.30.0/24      4          52483       3           N/A        xe48
10.10.10.1                LSP_DEFAULT
   L>   1.1.1.1/32         2          52481       3           N/A        xe48
10.10.10.1                LSP_DEFAULT
   L>   3.3.3.3/32         1          52480       3           N/A        xe5
20.20.20.2                LSP_DEFAULT
   L>   4.4.4.4/32         3          52482       24960       N/A        xe48
10.10.10.1                LSP_DEFAULT
```

```
   L>   40.40.40.0/24      5           52484       24961      N/A        xe48
10.10.10.1                LSP_DEFAULT
P1#show mpls ftn-table
 Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe48, out label: 3
    Nexthop addr: 10.10.10.1        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe48, out label: 24960
    Nexthop addr: 10.10.10.1        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 30.30.30.0/24, id: 2, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe48, out label: 3
    Nexthop addr: 10.10.10.1        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 4, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe48, out label: 24961
    Nexthop addr: 10.10.10.1        cross connect ix: 4, op code: Push
```

```
P1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          NL>     1.1.1.1             impl-null   No    10.10.10.1
2.2.2.2/32          E >     non-existent        none        No    connected
3.3.3.3/32          NL>     3.3.3.3             impl-null   No    20.20.20.2
4.4.4.4/32          NL>     1.1.1.1             24960       No    10.10.10.1
10.10.10.0/24       NL      1.1.1.1             impl-null   No    connected
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL      3.3.3.3             impl-null   No    connected
                    E >     non-existent        none        No    connected
30.30.30.0/24       NL>     1.1.1.1             impl-null   No    10.10.10.1
40.40.40.0/24       NL      3.3.3.3             impl-null   No    no nexthop
                    NL>     1.1.1.1             24961       No    10.10.10.1
```

Perform Link failure and check labels are retained until peer is reachable through alternate path.

(config)#interface xe12	Enter interface mode.
(config-if)#shutdown	Shutdown the link.
(config)#commit	commit.

Validation

After link down

```
PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
C            1.1.1.1/32 is directly connected, lo, 00:14:17
O            2.2.2.2/32 [110/33] via 30.30.30.2, xe6, 00:03:38
O            3.3.3.3/32 [110/32] via 30.30.30.2, xe6, 00:03:38
O            4.4.4.4/32 [110/31] via 30.30.30.2, xe6, 00:12:12
O            20.20.20.0/24 [110/32] via 30.30.30.2, xe6, 00:03:38
C            30.30.30.0/24 is directly connected, xe6, 00:12:57
O            40.40.40.0/24 [110/31] via 30.30.30.2, xe6, 00:12:12
    C            127.0.0.0/8 is directly connected, lo, 00:14:17
PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
```

```
4.4.4.4                  xe6        Passive   OPERATIONAL   30    00:10:10
2.2.2.2                  xe6        Passive   OPERATIONAL   30    00:10:56
PE1#show ldp targeted-peers
IP Address          Interface
2.2.2.2             xe6
4.4.4.4             xe6/
PE1#show ldp session 2.2.2.2
Session state          : OPERATIONAL
Session role           : Passive
TCP Connection         : Established
IP Address for TCP     : 2.2.2.2
Interface being used   : xe6
Peer LDP ID            : 2.2.2.2:0
Peer LDP Password      : Not Set
Adjacencies            : 2.2.2.2
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart       : Not Capable
Keepalive Timeout      : 30
Reconnect Interval     : 15
Session protection     : Protecting
Address List received : 2.2.2.2
                         20.20.20.1
                         254.128.0.0
Received Labels :        Fec              Label           Maps To
                IPV4:3.3.3.3/32         52480           none
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:2.2.2.2/32         impl-null       none
Sent Labels :   Fec                     Label           Maps To
                IPV4:40.40.40.0/24      24961           impl-null
                IPV4:4.4.4.4/32         24960           impl-null
                IPV4:30.30.30.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                    IPV4:1.1.1.1/32         impl-null       none

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         3         9         -           Yes   LSP_DEFAULT  24321
xe6         No    30.30.30.2
   L>   3.3.3.3/32         1         2         -           Yes   LSP_DEFAULT  24325
xe6         No    30.30.30.2
   L>   4.4.4.4/32         4         7         -           Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
```

```
   L>   20.20.20.0/24      2        4        -          Yes   LSP_DEFAULT  24326
xe6         No    30.30.30.2
   L>   40.40.40.0/24      5        8        -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe6, out label: 24321
    Nexthop addr: 30.30.30.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe6, out label: 24325
    Nexthop addr: 30.30.30.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe6, out label: 24326
    Nexthop addr: 30.30.30.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
```

```
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label   Out-Label   In-Intf   Out-Intf/VRF
Nexthop                    LSP-Type
   L>   40.40.40.0/24      2          24961       3           N/A        xe6
30.30.30.2                 LSP_DEFAULT
   L>   4.4.4.4/32         1          24960       3           N/A        xe6
30.30.30.2                 LSP_DEFAULT

P1#show ldp session
Peer IP Address            IF Name    My Role    State       KeepAlive  UpTime
3.3.3.3                    xe5        Passive   OPERATIONAL   30    00:11:12
1.1.1.1                    xe5        Active    OPERATIONAL   30    00:12:15
P1#show ldp targeted-peers
IP Address           Interface
1.1.1.1              xe5
    3.3.3.3              xe5

P1#show ldp session 1.1.1.1
Session state          : OPERATIONAL
Session role           : Active
TCP Connection         : Established
IP Address for TCP     : 1.1.1.1
Interface being used   : xe5
Peer LDP ID            : 1.1.1.1:0
Peer LDP Password      : Not Set
Adjacencies            : 1.1.1.1
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart       : Not Capable
Keepalive Timeout      : 30
Reconnect Interval     : 15
Session protection     : Protecting
Address List received : 1.1.1.1
                         30.30.30.1
                         254.128.0.0
Received Labels :        Fec              Label           Maps To
                IPV4:4.4.4.4/32        24960           52482
                IPV4:40.40.40.0/24     24961           52484
```

```
                IPV4:30.30.30.0/24      impl-null       52483
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:1.1.1.1/32         impl-null       52481
Sent Labels :   Fec                     Label           Maps To
                IPV4:3.3.3.3/32         52480           impl-null
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                    IPV4:2.2.2.2/32         impl-null       none

P1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         2         3         -          Yes   LSP_DEFAULT  24965
xe5         No    20.20.20.2
   L>   3.3.3.3/32         5         9         -          Yes   LSP_DEFAULT  3
xe5         No    20.20.20.2
   L>   4.4.4.4/32         3         5         -          Yes   LSP_DEFAULT  24966
xe5         No    20.20.20.2
   L>   30.30.30.0/24      4         7         -          Yes   LSP_DEFAULT  24967
xe5         No    20.20.20.2
   L>   40.40.40.0/24      1         1         -          Yes   LSP_DEFAULT  3
xe5         No    20.20.20.2
P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                   LSP-Type
   L>   4.4.4.4/32          3          52482       Nolabel     N/A        N/A
127.0.0.1                 LSP_DEFAULT
   L>   3.3.3.3/32          1          52480       3           N/A        xe5
20.20.20.2                LSP_DEFAULT
   L>   1.1.1.1/32          2          52481       Nolabel     N/A        N/A
127.0.0.1                 LSP_DEFAULT
   L>   30.30.30.0/24       4          52483       Nolabel     N/A        N/A
127.0.0.1                 LSP_DEFAULT
   L>   40.40.40.0/24       5          52484       Nolabel     N/A        N/A
127.0.0.1                 LSP_DEFAULT
P1#
P1#show mpls ftn-table
 Primary FTN entry with FEC: 1.1.1.1/32, id: 2, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 2
```

```
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe5, out label: 24965
    Nexthop addr: 20.20.20.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe5, out label: 24966
    Nexthop addr: 20.20.20.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 30.30.30.0/24, id: 4, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe5, out label: 24967
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 1, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


P1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
```

```
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
O            1.1.1.1/32 [110/53] via 20.20.20.2, xe5, 00:03:44
C            2.2.2.2/32 is directly connected, lo, 00:14:13
O            3.3.3.3/32 [110/2] via 20.20.20.2, xe5, 00:12:51
O            4.4.4.4/32 [110/52] via 20.20.20.2, xe5, 00:03:44
C            20.20.20.0/24 is directly connected, xe5, 00:13:46
O            30.30.30.0/24 [110/52] via 20.20.20.2, xe5, 00:03:44
O            40.40.40.0/24 [110/51] via 20.20.20.2, xe5, 00:03:44
C            127.0.0.0/8 is directly connected, lo, 00:14:13
```

Bring up the link and check same labels reused.

(config)#interface xe12	Enter interface mode.
(config-if)#no shutdown	Shutdown the link.
(config)#commit	Commit.

Validation

```
PE1#show ldp session
Peer IP Address            IF Name    My Role    State      KeepAlive  UpTime
4.4.4.4                    xe6        Passive   OPERATIONAL   30    00:14:55
2.2.2.2                    xe12       Passive   OPERATIONAL   30    00:15:41
PE1#show ldp targeted-peers
IP Address           Interface
2.2.2.2              xe12
4.4.4.4              xe6

PE1#show ldp session 2.2.2.2
Session state          : OPERATIONAL
Session role           : Passive
TCP Connection         : Established
IP Address for TCP     : 2.2.2.2
Interface being used   : xe12
Peer LDP ID            : 2.2.2.2:0
Peer LDP Password      : Not Set
Adjacencies            : 10.10.10.2
                         2.2.2.2
Advertisement mode     : Downstream Unsolicited
Label retention mode   : Liberal
Graceful Restart       : Not Capable
Keepalive Timeout      : 30
Reconnect Interval     : 15
Session protection     : Ready
Address List received : 2.2.2.2
```

```
                        10.10.10.2
                        20.20.20.1
                        254.128.0.0
Received Labels :       Fec               Label           Maps To
                IPV4:3.3.3.3/32         52480           24966
                IPV4:20.20.20.0/24      impl-null       24967
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:2.2.2.2/32         impl-null       24965
Sent Labels :   Fec                     Label           Maps To
                IPV4:40.40.40.0/24      24961           impl-null
                IPV4:4.4.4.4/32         24960           impl-null
                IPV4:30.30.30.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:1.1.1.1/32         impl-null       none

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         3        9         -          Yes   LSP_DEFAULT  3
xe12        No    10.10.10.2
   L>   3.3.3.3/32         1        2         -          Yes   LSP_DEFAULT  52480
xe12        No    10.10.10.2
   L>   4.4.4.4/32         4        7         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
   L>   20.20.20.0/24      2        4         -          Yes   LSP_DEFAULT  3
xe12        No    10.10.10.2
   L>   40.40.40.0/24      5        8         -          Yes   LSP_DEFAULT  3
xe6         No    30.30.30.2
PE1#
PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                  LSP-Type
   L>   2.2.2.2/32        9          24965       3           N/A        xe12
10.10.10.2               LSP_DEFAULT
   L>   40.40.40.0/24     2          24961       3           N/A        xe6
30.30.30.2               LSP_DEFAULT
   L>   4.4.4.4/32        1          24960       3           N/A        xe6
30.30.30.2               LSP_DEFAULT
   L>   3.3.3.3/32        10         24966       52480       N/A        xe12
10.10.10.2               LSP_DEFAULT
```

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```
   L>   20.20.20.0/24      11          24967      3          N/A        xe12
10.10.10.2                 LSP_DEFAULT
PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe12, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe12, out label: 52480
    Nexthop addr: 10.10.10.2        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 20.20.20.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe12, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe6, out label: 3
```

```
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push


P1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
3.3.3.3                   xe5        Passive   OPERATIONAL   30    00:15:30
    1.1.1.1                   xe48       Active    OPERATIONAL   30    00:16:33

P1#show ldp targeted-peers
IP Address          Interface
1.1.1.1             xe48
3.3.3.3             xe5

P1#show ldp session 1.1.1.1
Session state         : OPERATIONAL
Session role          : Active
TCP Connection        : Established
IP Address for TCP    : 1.1.1.1
Interface being used  : xe48
Peer LDP ID           : 1.1.1.1:0
Peer LDP Password     : Not Set
Adjacencies           : 10.10.10.1
                        1.1.1.1
Advertisement mode    : Downstream Unsolicited
Label retention mode  : Liberal
Graceful Restart      : Not Capable
Keepalive Timeout     : 30
Reconnect Interval    : 15
Session protection    : Ready
Address List received : 1.1.1.1
                        10.10.10.1
                        30.30.30.1
                        254.128.0.0
Received Labels :       Fec               Label           Maps To
                IPV4:4.4.4.4/32        24960           52482
                IPV4:40.40.40.0/24     24961           52484
                IPV4:30.30.30.0/24     impl-null       52483
                IPV4:10.10.10.0/24     impl-null       none
                IPV4:1.1.1.1/32        impl-null       52481
Sent Labels :   Fec                    Label           Maps To
                IPV4:3.3.3.3/32        52480           impl-null
                IPV4:20.20.20.0/24     impl-null       none
                IPV4:10.10.10.0/24     impl-null       none
                    IPV4:2.2.2.2/32        impl-null       none

P1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN
```

```
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         2         3         -           Yes   LSP_DEFAULT  3
xe48        No    10.10.10.1
   L>   3.3.3.3/32         5         9         -           Yes   LSP_DEFAULT  3
xe5         No    20.20.20.2
   L>   4.4.4.4/32         3         5         -           Yes   LSP_DEFAULT  24960
xe48        No    10.10.10.1
   L>   30.30.30.0/24      4         7         -           Yes   LSP_DEFAULT  3
xe48        No    10.10.10.1
   L>   40.40.40.0/24      1         1         -           Yes   LSP_DEFAULT  24961
xe48        No    10.10.10.1

P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                   LSP-Type
   L>   4.4.4.4/32        3           52482       24960       N/A        xe48
10.10.10.1                LSP_DEFAULT
   L>   1.1.1.1/32        2           52481       3           N/A        xe48
10.10.10.1                LSP_DEFAULT
   L>   3.3.3.3/32        1           52480       3           N/A        xe5
20.20.20.2                LSP_DEFAULT
   L>   40.40.40.0/24     5           52484       24961       N/A        xe48
10.10.10.1                LSP_DEFAULT
   L>   30.30.30.0/24     4           52483       3           N/A        xe48
10.10.10.1                LSP_DEFAULT

P1#show mpls ftn-table
 Primary FTN entry with FEC: 1.1.1.1/32, id: 2, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe48, out label: 3
    Nexthop addr: 10.10.10.1        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe5, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push
```

```
 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe48, out label: 24960
    Nexthop addr: 10.10.10.1        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 30.30.30.0/24, id: 4, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe48, out label: 3
    Nexthop addr: 10.10.10.1        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 1, row status: Active
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe48, out label: 24961
    Nexthop addr: 10.10.10.1        cross connect ix: 8, op code: Push
```

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CHAPTER 2 LDP Inter-Area Configuration

This chapter contains LDP inter-area configuration examples.

Overview

Provider-based MPLS (Multiprotocol Label Switching) networks are expanding with the success of Layer 3 Virtual Private Networks and the new deployments of Layer 2 VPNs. Service providers MPLS backbones are significantly growing both in terms of density with the addition of Provider Edge (PE) routers to connect new customers and in terms of footprint as traditional Layer 2 aggregation networks may be replaced by IP/MPLS networks. As a consequence, many providers need to introduce IGP areas. Inter-area LSPs (that is, LSPs that traverse at least two IGP areas) are required to ensure MPLS connectivity between PEs located in distinct IGP areas.

On a large MPLS networks, multiple IGP areas need to be configured for flexible network deployment and fast route convergence. When advertising routes between IGP areas, to prevent a large number of routes from consuming too many resources, an Area Border Router (ABR) needs to aggregate the routes in the area and advertises the aggregated route to the neighboring IGP areas. By default, when establishing LSPs, LDP searches the routing table for the route that exactly matches the FEC in the received Label Mapping message.

The LDP inter-area feature provides a longest-match label mapping procedure where a label is used if the Forwarding Equivalence Class (FEC) matches an entry in the Routing Information Base (RIB). Matching is defined by an IP longest-match search and does not mandate an exact match.

Configure LDP Inter-Area

The LDP Inter-Area configuration process can be divided into the following tasks:

1. Enable label-switching on the interface in NSM.
2. Enable LDP on an interface in LDP.
3. Run an IGP (Internal Gateway Protocol) such as OSPF or ISIS to distribute reachability information within the MPLS cloud.
4. Give the `inter-area-lsp` command in LDP router mode to enable creation of inter-area LSPs.

To configure a summary route on an ABR, configure two networks such R4 and R5 in Figure 2-1, so that two prefixes are summarized. For example, 4.4.4.0/24 is a summary route for the networks 4.4.4.1/32 and 4.4.4.2/32.

Give the `area-range` command on the routers to summarize the networks. For example: area 2 range 4.4.4.0/24.

Note: LDP Downstream-On-Demand not supported with inter-area configuration. LDP Inter-Area Graceful Restart (GR) is not supported in this release.

Topology

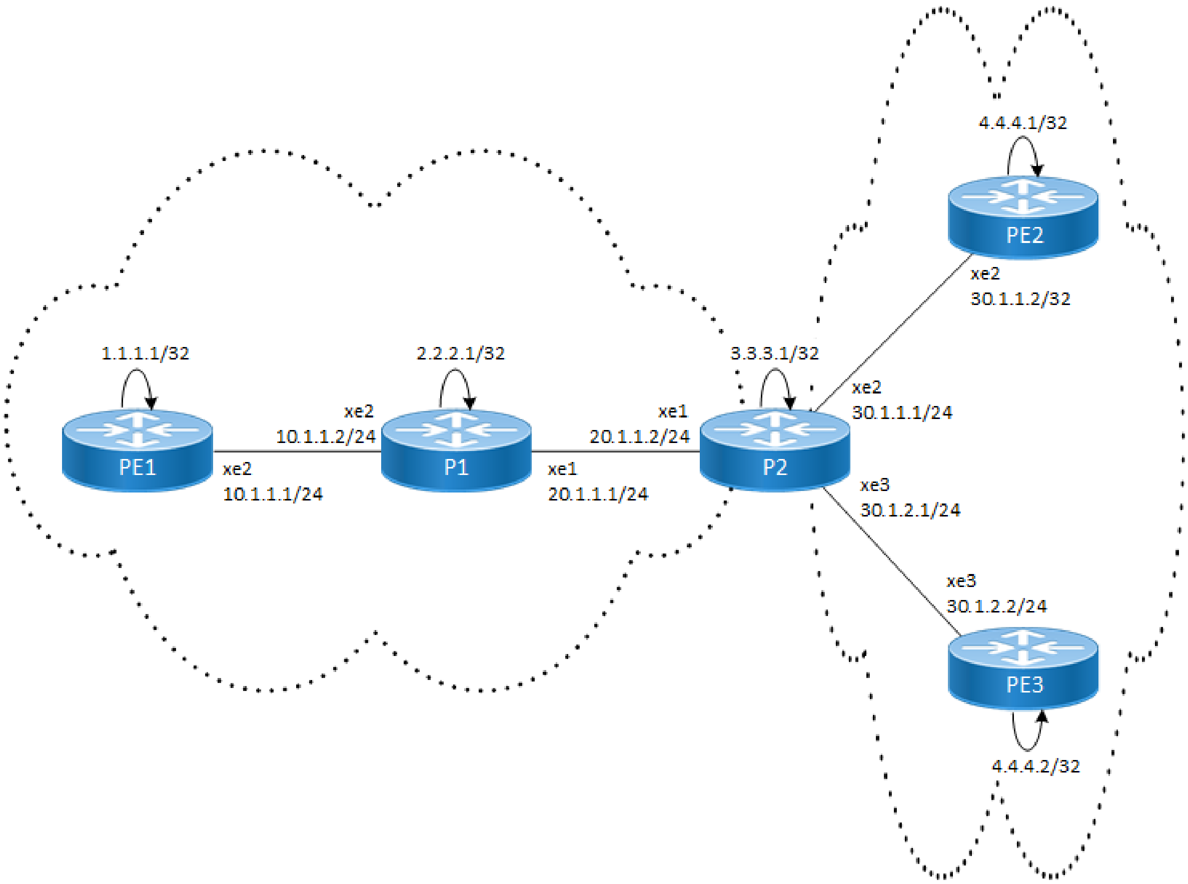

Figure 2-1: LDP inter-area topology

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter loopback interface mode.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to 1.1.1.1/32.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 4.4.4.1`	Configure targeted peer.
`(config-router-targeted-peer)#targeted-peer ipv4 4.4.4.2`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode.
`(config)#interface xe2`	Enter interface mode.

(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.1/24	Set the IP address of the interface to 10.1.1.1/24
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 1.1.1.1/32 area 0 (config-router)#network 10.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter LDP router mode.
(config-router)#inter-area-lsp	Enable the inter-area-LSP command.
(config-router)#commit	Commit the transaction.

P1

#configure terminal	Enter configure mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 2.2.2.1	Set the router ID to IP address 2.2.2.1
(config-router)#transport-address ipv4 2.2.2.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 2.2.2.1/32	Set the IP address of the loopback interface to 2.2.2.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.2/24	Set the IP address of the interface to 10.1.1.2/24
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#ip address 20.1.1.1/24	Set the IP address of the interface to 20.1.1.1/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).

(config-router)#network 2.2.2.1/32 area 0 (config-router)#network 10.1.1.0/24 area 0 (config-router)#network 20.1.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter LDP router mode.
(config-router)#inter-area-lsp	Enable the inter-area-LSP command.
(config-router)#commit	Commit the transaction.

P2

#configure terminal	Enter configure mode.
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 3.3.3.1/32 secondary	Set the IP address of the loopback interface to 3.3.3.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.1.1.2/24	Set the IP address of the interface to 20.1.1.2/24
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#ip address 30.1.1.1/24	Set the IP address of the interface to 30.1.1.1/24
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#label-switching	Enable label switching on interface xe1.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#ip address 30.1.2.1/24	Set the IP address of the interface to 30.1.2.1/24
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 3.3.3.1/32 area 0 (config-router)#network 20.1.1.0/24 area 0 (config-router)#network 30.1.1.0/24 area 2 (config-router)#network 30.1.2.0/24 area 2	Define the interface on which OSPF runs and associate the area ID (0 and 2) respectively with the interface.
(config)#router ldp	Enter LDP router mode.

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(config-router)#transport-address ipv4 3.3.3.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#router-id 3.3.3.1	Set the router ID to IP address 3.3.3.1
(config-router)#exit	Exit router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe1.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe3.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#area 2 range 4.4.4.0/24	Configure the summary route with range command.
(config-router)#commit	Commit the transaction.

PE2

#configure terminal	Enter configure mode.
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 4.4.4.1/32 secondary	Set the IP address of the loopback interface to 4.4.4.1/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 30.1.1.2/24	Set the IP address of the interface to 30.1.1.2/24
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 4.4.4.1/32 area 2 (config-router)#network 30.1.1.0/24 area 2	Define the interface on which OSPF runs and associate the area ID (2) with the interface.
(config)#router ldp	Enter LDP router mode.
(config-router)#router-id 4.4.4.1	Set the router ID to IP address to 4.4.4.1
(config-router)#transport-address ipv4 4.4.4.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe2	Enter interface mode.

(config-if)#enable-ldp ipv4	Enable LDP on xe2.
(config-if)#commit	Commit the transaction.

PE3

#configure terminal	Enter configure mode.
(config)#interface xe3	Specify the interface (xe3) to be configured.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter loopback interface mode.
(config-if)#ip address 4.4.4.2/32 secondary	Set the IP address of the loopback interface to 4.4.4.2/32.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 30.1.2.2/24	Set the IP address of the interface to 30.1.2.2/24
(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
(config-router)#network 4.4.4.2/32 area 2 (config-router)#network 30.1.2.0/24 area 2	Define the interface on which OSPF runs and associate the area ID (2) with the interface.
(config)#router ldp	Enter LDP router mode.
(config-router)#router-id 4.4.4.2	Set the router ID to IP address to 4.4.4.2
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#exit	Exit router mode.
(config)#interface xe3	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP on xe3.
(config-if)#commit	Commit the transaction.

Validation

PE1

```
PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
```

```
K*           0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C            1.1.1.1/32 is directly connected, lo, 00:30:03
O            2.2.2.1/32 [110/2] via 10.1.1.2, xe2, 00:19:09
O            3.3.3.1/32 [110/3] via 10.1.1.2, xe2, 00:12:28
O IA         4.4.4.0/24 [110/4] via 10.1.1.2, xe2, 00:08:42
C            10.1.1.0/24 is directly connected, xe2, 00:29:06
C            10.12.49.0/24 is directly connected, xe0, 01:32:26
O            20.1.1.0/24 [110/2] via 10.1.1.2, xe2, 00:19:09
O IA         30.1.1.0/24 [110/3] via 10.1.1.2, xe2, 00:12:28
O IA         30.1.2.0/24 [110/3] via 10.1.1.2, xe2, 00:12:28
C            127.0.0.0/8 is directly connected, lo, 01:33:35
PE1#show ldp inter-area-fecs
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
                L - LSR received a label for this FEC,
                > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
Matching RIB prefix - 4.4.4.0/24
4.4.4.1/32          NL>     2.2.2.1             25605       No    10.1.1.2
4.4.4.2/32          NL>     2.2.2.1             25606       No    10.1.1.2

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label    Out-Intf    ELC
Nexthop
   L>   2.2.2.1/32          1         2         -           Yes   LSP_DEFAULT  3            xe2         No
10.1.1.2
   L>   3.3.3.1/32          3         3         -           Yes   LSP_DEFAULT  25600        xe2         No
10.1.1.2
   L>   4.4.4.0/24          6         6         -           Yes   LSP_DEFAULT  25604        xe2         No
10.1.1.2
   L>   4.4.4.1/32          7         7         -           Yes   LSP_DEFAULT  25605        xe2         No
10.1.1.2
   L>   4.4.4.2/32          8         1         -           Yes   LSP_DEFAULT  25606        xe2         No
10.1.1.2
   L>   20.1.1.0/24         2         2         -           Yes   LSP_DEFAULT  3            xe2         No
10.1.1.2
   L>   30.1.1.0/24         4         4         -           Yes   LSP_DEFAULT  25601        xe2         No
10.1.1.2
   L>   30.1.2.0/24         5         5         -           Yes   LSP_DEFAULT  25602        xe2         No
10.1.1.2

PE1#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
2.2.2.1                  xe2        Passive   OPERATIONAL   30    00:19:02
```

P1

```
P1#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
1.1.1.1                  xe2        Active    OPERATIONAL   30    00:22:11
3.3.3.1                  xe1        Passive   OPERATIONAL   30    00:16:34

P1#show ldp inter-area-fecs
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
                L - LSR received a label for this FEC,
                > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
```

```
Matching RIB prefix - 4.4.4.0/24
4.4.4.1/32          NL>     3.3.3.1             25600       No    20.1.1.2
4.4.4.2/32          NL>     3.3.3.1             25604       No    20.1.1.2
```

```
P1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID     Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label     Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32          1          2         -           Yes   LSP_DEFAULT  3             xe1         No    10.1.1.1
   L>   3.3.3.1/32          2          3         -           Yes   LSP_DEFAULT  3             xe1         No    20.1.1.2
   L>   4.4.4.0/24          6          3         -           Yes   LSP_DEFAULT  3             xe1         No    20.1.1.2
   L>   4.4.4.1/32          5          4         -           Yes   LSP_DEFAULT  25600         xe1         No    20.1.1.2
   L>   4.4.4.2/32          7          1         -           Yes   LSP_DEFAULT  25604         xe1         No    20.1.1.2
   L>   30.1.1.0/24         3          3         -           Yes   LSP_DEFAULT  3             xe1         No    20.1.1.2
   L>   30.1.2.0/24         4          3         -           Yes   LSP_DEFAULT  3             xe1         No    20.1.1.2
```

```
P1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O             1.1.1.1/32 [110/2] via 10.1.1.1, xe2, 00:28:05
C             2.2.2.1/32 is directly connected, lo, 00:29:56
O             3.3.3.1/32 [110/2] via 20.1.1.2, xe1, 00:21:28
O IA          4.4.4.0/24 [110/3] via 20.1.1.2, xe1, 00:17:41
C             10.1.1.0/24 is directly connected, xe2, 00:29:29
C             10.12.49.0/24 is directly connected, xe0, 01:26:43
C             20.1.1.0/24 is directly connected, xe1, 00:29:06
O IA          30.1.1.0/24 [110/2] via 20.1.1.2, xe1, 00:21:28
O IA          30.1.2.0/24 [110/2] via 20.1.1.2, xe1, 00:21:28
C             127.0.0.0/8 is directly connected, lo, 01:30:20
```

P2

```
P2#show ldp session
Peer IP Address            IF Name    My Role    State       KeepAlive  UpTime
2.2.2.1                    xe1       Active    OPERATIONAL   30    00:18:30
4.4.4.1                    xe2       Passive   OPERATIONAL   30    00:13:42
4.4.4.2                    xe3       Passive   OPERATIONAL   30    00:08:51
```

```
P2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

```
Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label     Out-Intf     ELC    Nexthop
   L>   1.1.1.1/32        1         1         -           Yes   LSP_DEFAULT  25603          xe1         No     20.1.1.1
   L>   2.2.2.1/32        2         2         -           Yes   LSP_DEFAULT  3             xe1         No     20.1.1.1
   L>   4.4.4.1/32        4         3         -           Yes   LSP_DEFAULT  3             xe2         No     30.1.1.2
   L>   4.4.4.2/32        5         4         -           Yes   LSP_DEFAULT  3             xe3         No     30.1.2.2
   L>   10.1.1.0/24       3         2         -           Yes   LSP_DEFAULT  3             xe1         No     20.1.1.1

P2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O             1.1.1.1/32 [110/3] via 20.1.1.1, xe1, 00:20:52
O             2.2.2.1/32 [110/2] via 20.1.1.1, xe1, 00:20:52
C             3.3.3.1/32 is directly connected, lo, 00:23:04
O             4.4.4.0/24 [110/0] is a summary, Null, 00:17:09
O             4.4.4.1/32 [110/2] via 30.1.1.2, xe2, 00:17:09
O             4.4.4.2/32 [110/2] via 30.1.2.2, xe3, 00:10:38
O             10.1.1.0/24 [110/2] via 20.1.1.1, xe1, 00:20:52
C             10.12.49.0/24 is directly connected, xe0, 01:33:43
C             20.1.1.0/24 is directly connected, xe1, 00:22:46
C             30.1.1.0/24 is directly connected, xe2, 00:22:15
C             30.1.2.0/24 is directly connected, xe3, 00:21:48
C             127.0.0.0/8 is directly connected, lo, 01:35:10
```

PE2

```
PE2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
3.3.3.1                   xe2       Active    OPERATIONAL   30    00:14:56

PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intfh    ELC   Nexthop
   L>   1.1.1.1/32         1         1         -           Yes   LSP_DEFAULT  25601
xe2         No    30.1.1.1
   L>   2.2.2.1/32         2         2         -           Yes   LSP_DEFAULT  25602
xe2         No    30.1.1.1
```

```
   L>   3.3.3.1/32         3        3        -          Yes   LSP_DEFAULT  3
xe2       No   30.1.1.1
   L>   4.4.4.2/32         7        5        -          Yes   LSP_DEFAULT  25605
xe2       No   30.1.1.1
   L>   10.1.1.0/24        4        4        -          Yes   LSP_DEFAULT  25603
xe2       No   30.1.1.1
   L>   20.1.1.0/24        5        3        -          Yes   LSP_DEFAULT  3
xe2       No   30.1.1.1
   L>   30.1.2.0/24        6        3        -          Yes   LSP_DEFAULT  3
xe2         No    30.1.1.1

PE2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*           0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O IA         1.1.1.1/32 [110/4] via 30.1.1.1, xe2, 00:16:46
O IA         2.2.2.1/32 [110/3] via 30.1.1.1, xe2, 00:16:46
O IA         3.3.3.1/32 [110/2] via 30.1.1.1, xe2, 00:16:46
C            4.4.4.1/32 is directly connected, lo, 00:17:38
O            4.4.4.2/32 [110/3] via 30.1.1.1, xe2, 00:10:22
O IA         10.1.1.0/24 [110/3] via 30.1.1.1, xe2, 00:16:46
C            10.12.49.0/24 is directly connected, xe0, 01:24:27
O IA         20.1.1.0/24 [110/2] via 30.1.1.1, xe2, 00:16:46
C            30.1.1.0/24 is directly connected, xe2, 00:17:22
O            30.1.2.0/24 [110/2] via 30.1.1.1, xe2, 00:16:46
C            127.0.0.0/8 is directly connected, lo, 01:26:08
```

PE3

```
PE3#show ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
3.3.3.1                   xe3       Active    OPERATIONAL   30    00:12:50

PE3#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label    Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32        1         1         -           Yes   LSP_DEFAULT  25606        xe3        No    30.1.2.1
   L>   2.2.2.1/32        2         2         -           Yes   LSP_DEFAULT  25607        xe3        No    30.1.2.1
   L>   3.3.3.1/32        3         3         -           Yes   LSP_DEFAULT  3            xe3        No    30.1.2.1
   L>   4.4.4.1/32        4         4         -           Yes   LSP_DEFAULT  25608        xe3        No    30.1.2.1
   L>   10.1.1.0/24       5         5         -           Yes   LSP_DEFAULT  25609        xe3        No    30.1.2.1
   L>   20.1.1.0/24       6         3         -           Yes   LSP_DEFAULT  3            xe3        No    30.1.2.1
   L>   30.1.1.0/24       7         3         -           Yes   LSP_DEFAULT  3            xe3        No    30.1.2.1
```

```
PE3#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O IA          1.1.1.1/32 [110/4] via 30.1.2.1, xe3, 00:13:04
O IA          2.2.2.1/32 [110/3] via 30.1.2.1, xe3, 00:13:04
O IA          3.3.3.1/32 [110/2] via 30.1.2.1, xe3, 00:13:04
O             4.4.4.1/32 [110/3] via 30.1.2.1, xe3, 00:13:04
C             4.4.4.2/32 is directly connected, lo, 00:16:39
O IA          10.1.1.0/24 [110/3] via 30.1.2.1, xe3, 00:13:04
C             10.12.49.0/24 is directly connected, xe0, 00:57:36
O IA          20.1.1.0/24 [110/2] via 30.1.2.1, xe3, 00:13:04
O             30.1.1.0/24 [110/2] via 30.1.2.1, xe3, 00:13:04
C             30.1.2.0/24 is directly connected, xe3, 00:13:22
C             127.0.0.0/8 is directly connected, lo, 00:59:09
```

CHAPTER 3 MPLS LDP-IGP Synchronization

This chapter contains configurations for MPLS LDP-IGP Synchronization.

Overview

Multi-Protocol Label Switching (MPLS) Label Distribution Protocol (LDP) Interior Gateway Protocol (IGP) Synchronization ensures that LDP is fully established before the IGP path is used for switching. In certain networks, there is dependency on the edge-to-edge Label Switched Paths (LSPs) setup by the Label Distribution Protocol (LDP), e.g., networks that are used for Multi-Protocol Label Switching (MPLS) Virtual Private Network (VPN) applications. For such applications, it is not possible to rely on Internet Protocol (IP) forwarding if the MPLS LSP is not operating appropriately. Labeled traffic can be dropped due to presence of black holes in situations where the Interior Gateway Protocol (IGP) is operational on a link but LDP sessions are not up as the label distribution is not completed. While the link could still be used for IP forwarding, it is not useful for MPLS forwarding, for example, MPLS VPN applications or Border Gateway Protocol (BGP) route-free cores.

The MPLS LDP-IGP Synchronization feature ensures that the Label Distribution Protocol (LDP) is fully established before the Interior Gateway Protocol (IGP) path is used for packet forwarding. It is useful for cases in which the router is the ingress and the decision of whether to take the MPLS LSP or IGP path is decided there.

LDP-IGP synchronization is an interface level feature. It can be selectively enabled in the required interfaces. For each interface there are two commands available for synchronization, one each for IS-IS. Once configured the IGP saves the required information, and also notifies LDP. In between the IGP increases the link cost to maximum and sends advertisements to its peer. This discourages its peers from taking routes that pass via it.

When all LDP sessions hosted on the interface become operational, it sends a notification to the IGP. This is termed as LDP convergence. The IGP then advertises normal cost, so that all traffic now coming to the interface takes the MPLS LSP path established by LDP and not be IP routed.

Prerequisites

Only interfaces that are running Open Shortest Path First (OSPF) or Intermediate System-to-Intermediate System (IS-IS) processes are capable of LDP-IGP synchronization. The router must also be running LDP.

Topology

The sample topology diagram is applicable to all configurations in this chapter.

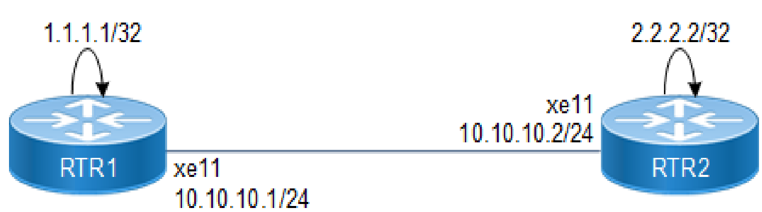

Figure 3-2: Sample Topology for LDP-IGP Synchronization

LDP-IGP Synchronization with OSPF

When IGP synchronization is enabled on OSPF-enabled interfaces, OSPF sends Maximum/Normal cost based on LDP session Down or Up state messages to interfaces until the hold-down-timer expires or synchronization is achieved.

Before configuring LDP-IGP synchronization, the NSM, OSPF and LDP configurations must be completed. The tables below contain examples of how this is done.

RTR1 - NSM

`#configure terminal`	Enter configuration mode.
`(config)#interface xe11`	Enter interface mode.
`(config-if)#ip address 10.10.10.1/24`	Configure IPv4 address for xe11.
`(config-if)#label-switching`	Enable label switching on interface xe11.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to 1.1.1.1/32.
`(config-if)#commit`	Commit the transaction.

RTR1 - OSPF

`(config)#router ospf 100`	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#ospf router-id 1.1.1.1`	Configure OSPF router ID same as loopback IP address.
`(config-router)#network 10.10.10.0/24 area 0` `(config-router)#network 1.1.1.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.

RTR1 - LDP

`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1.
`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode.
`(config)#interface xe11`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe11.
`(config-if)#commit`	Commit the transaction.

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RTR2 - NSM

`#configure terminal`	Enter configuration mode.
`(config)#interface xe11`	Enter interface mode.
`(config-if)#ip address 10.10.10.2/24`	Configure IPv4 address for xe11.
`(config-if)#label-switching`	Enable label switching on interface xe11.
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to 2.2.2.2/32.
`(config-if)#commit`	Commit the transaction.

RTR2 - OSPF

`(config)#router ospf 100`	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#ospf router-id 2.2.2.2`	Configure OSPF router ID same as loopback IP address.
`(config-router)#network 10.10.10.0/24 area 0` `(config-router)#network 2.2.2.2/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.

RTR2 - LDP

`(config)#router ldp`	Enter Router mode for LDP.
`(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2.
`(config-router)#transport-address ipv4 2.2.2.2`	Configure the transport address for IPV4 (for IPV6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as transport address.
`(config-router)#exit`	Exit the Router mode and return to the Configure mode.
`(config)#interface xe11`	Enter interface mode.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe11.
`(config-if)#commit`	Commit the transaction.

Validation

```
R1#show ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/DR        00:00:33   10.10.10.2     xe11
0
```

```
R2#show ip ospf neighbor

Total number of full neighbors: 1
OSPF process 100 VRF(default):
Neighbor ID    Pri   State          Dead Time   Address        Interface
Instance ID
1.1.1.1         1   Full/Backup     00:00:31   10.10.10.1     xe11
0

R1#show ldp session
Peer IP Address          IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2                  xe11       Passive   OPERATIONAL   30    00:06:03

R2#show ldp session
Peer IP Address          IF Name    My Role    State      KeepAlive  UpTime
1.1.1.1                  xe11       Active    OPERATIONAL   30    00:06:31

R1#show ldp adjacency
Remote-Address  Local-Address   Mode     Intf-Name  Holdtime   LDP-Identifier
10.10.10.2      10.10.10.1      Interface     xe11        15         2.2.2.2:0


R2#show ldp adjacency
Remote-Address  Local-Address   Mode     Intf-Name  Holdtime   LDP-Identifier
10.10.10.1      10.10.10.2      Interface     xe11        15         1.1.1.1:0

R1#show ip ospf interface
lo is up, line protocol is up
  Internet Address 1.1.1.1/32, Area 0.0.0.0, MTU 16436
  Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type LOOPBACK,
Cost: 1
  Transmit Delay is 1 sec,  State Loopback, TE Metric 1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
xe11 is up, line protocol is up
  Internet Address 10.10.10.1/24, Area 0.0.0.0, MTU 1500
  Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type BROADCAST,
Cost: 1
  Transmit Delay is 1 sec,  State Backup, Priority 1, TE Metric 1
  Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
  Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 61 sent 62, DD received 3 sent 6
  LS-Req received 1 sent 1, LS-Upd received 4 sent 5
  LS-Ack received 4 sent 3, Discarded 0
  No authentication

R2#show ip ospf interface
lo is up, line protocol is up
  Internet Address 2.2.2.2/32, Area 0.0.0.0, MTU 16436
  Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type LOOPBACK,
Cost: 1
  Transmit Delay is 1 sec,  State Loopback, TE Metric 1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
xe11 is up, line protocol is up
  Internet Address 10.10.10.2/24, Area 0.0.0.0, MTU 1500
```

```
  Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type BROADCAST,
Cost: 1
  Transmit Delay is 1 sec,  State DR, Priority 1, TE Metric 1
  Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
  Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 62 sent 63, DD received 6 sent 3
  LS-Req received 1 sent 1, LS-Upd received 5 sent 4
  LS-Ack received 3 sent 4, Discarded 0
  No authentication
```

LDP-IGP Synchronization

Now that NSM, OSPF and LDP are all enabled, the LDP-IGP synchronization can be configured.

RTR1

`(config)#interface xe11`	Enter interface mode.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe11 belonging to an OSPF process and 500 seconds is holddown-timer value for IGP to wait until LDP converges. **OSPF:** This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#mpls ldp-igp sync-delay 60`	Configure time delay in seconds for notification of LDP convergence to IGP. This is not applicable for notification of non-convergence. Range is 5 to 60 seconds. This command is optional. **LDP:** This command is part of LDP Process. **Default:** If not configured the delay is 0 seconds.
`(config-if)#commit`	Commit the transaction.

RTR2

`(config)#interface xe11`	Enter interface mode.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for interfaces (xe11) belonging to an OSPF process.and 500 secs is Holddown-timer value for IGP to wait until LDP Converge. **OSPF:** This command is part of the OSPF Process.vNote: Holddown-timer range is <1-2147483> seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use command mpls ldp-igp sync ospf to configure without a holddown-timer.

(config-if)#mpls ldp-igp sync-delay 60	Configure the time delay in seconds for the notification of LDP convergence to IGP. (This is not applicable for notification of non-convergence.) Range is 5 to 60 seconds. This command is optional. **LDP:** This command is part of LDP Process. **Default:** If not configured the delay is 0 seconds.
(config-if)#commit	Commit the transaction.

RTR1 Validation

When LDP IGP SYNC is Configured with hold-down and sync-delay timer

```
R1#show ip ospf interface
lo is up, line protocol is up
  Internet Address 1.1.1.1/32, Area 0.0.0.0, MTU 16436
  Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type LOOPBACK,
Cost:
 1
  Transmit Delay is 1 sec,  State Loopback, TE Metric 1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
xe11 is up, line protocol is up
  Internet Address 10.10.10.1/24, Area 0.0.0.0, MTU 1500
  Process ID 100, VRF (default), Router ID 1.1.1.1, Network Type BROADCAST,
Cost
: 1
  Transmit Delay is 1 sec,  State Backup, Priority 1, TE Metric 1
  LDP-OSPF Sync configured
    Holddown timer : 500 seconds, Remaining time = 0 seconds
  Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
  Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:06
  Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 178 sent 179, DD received 3 sent 6
  LS-Req received 1 sent 1, LS-Upd received 5 sent 6
  LS-Ack received 5 sent 4, Discarded 0
  No authentication

R1#show mpls ldp igp sync
xe11 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 2.2.2.2
    Sync status: Achieved
    Delay timer: Configured, 60 seconds, Not Running
```

RTR2 Validation

```
R2#show ip ospf interface
lo is up, line protocol is up
  Internet Address 2.2.2.2/32, Area 0.0.0.0, MTU 16436
  Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type LOOPBACK,
Cost:
 1
  Transmit Delay is 1 sec,  State Loopback, TE Metric 1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
xe11 is up, line protocol is up
```

```
  Internet Address 10.10.10.2/24, Area 0.0.0.0, MTU 1500
  Process ID 100, VRF (default), Router ID 2.2.2.2, Network Type BROADCAST,
Cost
: 1
  Transmit Delay is 1 sec,  State DR, Priority 1, TE Metric 1
  LDP-OSPF Sync configured
    Holddown timer : 500 seconds, Remaining time = 0 seconds
  Designated Router (ID) 2.2.2.2, Interface Address 10.10.10.2
  Backup Designated Router (ID) 1.1.1.1, Interface Address 10.10.10.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
  Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 211 sent 211, DD received 6 sent 3
  LS-Req received 1 sent 1, LS-Upd received 8 sent 7
  LS-Ack received 6 sent 7, Discarded 0
  No authentication

R2#show mpls ldp igp sync
xe11 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 1.1.1.1
    Sync status: Achieved
    Delay timer: Configured, 60 seconds, Not Running
```

LDP-IGP Synchronization with IS-IS

When IGP synchronization is enabled on an IS-IS enabled interfaces, IS-IS sends Maximum/Normal cost based on LDP session or Up state on interfaces until hold-down-timer expires or synchronization is achieved.

Before configuring LDP-IGP synchronization, the NSM, IS-IS and LDP configurations must be completed. The tables below contain examples of how this is done.

RTR1 - NSM

#configure terminal	Enter configuration mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 10.10.10.1/24	Set the IP address of the xe11 to 10.10.10.1/24.
(config-if)#label-switching	Enable label switching on xe11.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-if)#commit	Commit the transaction.

RTR1 - IS-IS

(config)#router isis 1	Configure the IS-IS routing instance and specify the TAG (1). The TAG should be a WORD - ISO routing area tag.
(config-router)#is-type level-1	Define the IS to the specified level of routing for router.
(config-router)#net 49.0001.0000.0000.0001.00	Configure the Network Entity Title (NET) for the instance.

(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level 1.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode for the loopback interface (lo).
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level 1.
(config-if)#commit	Commit the transaction.

RTR1 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.
(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address for IPV4 (for IPv6 use an IPv6 address) to use for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe11.
(config-if)#commit	Commit the transaction.

RTR2 - NSM

#configure terminal	Enter configuration mode
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 10.10.10.2/24	Set the IP address of xe11 to 10.10.10.2/24
(config-if)#label-switching	Enable label switching on interface xe11.
(config-if)#exit	Exit interface mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
(config-if)#commit	Commit the transaction.

RTR2 - IS-IS

(config)#router isis 1	Configure the IS-IS routing instance and specify the TAG as 1. The TAG should be a WORD - ISO routing area tag.
(config-router)#is-type level-1	Define the IS to the specified level of routing for router.
(config-router)#net 49.0001.0000.0000.0002.00	Configure the Network Entity Title (NET) for the instance.

(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with is-is tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level type (1).
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode for the loopback (lo) interface.
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#isis circuit-type level-1	Define the circuit type for the interface on which IS-IS runs and associate the level 1.
(config-if)#commit	Commit the transaction.

RTR2 - LDP

(config)#router ldp	Enter Router mode for LDP.
(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address for IPv4 (for IPv6 use an IPv6 address) to use for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as transport address.
(config-router)#exit	Exit the Router mode and return to the Configure mode.
(config)#interface xe11	Enter interface mode.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe11.
(config-if)#commit	Commit the transaction.

Validation

```
R1#show clns neighbors

Total number of L1 adjacencies: 1
Total number of L2 adjacencies: 0
Total number of adjacencies: 1
Tag 1:  VRF : default
System Id      Interface   SNPA                State   Holdtime   Type Protocol
0000.0000.0002 xe11        6cb9.c5cf.da69      Up      24         L1   IS-IS

R2#show clns neighbors

Total number of L1 adjacencies: 1
Total number of L2 adjacencies: 0
Total number of adjacencies: 1
Tag 1:  VRF : default
System Id      Interface   SNPA                State   Holdtime   Type Protocol
0000.0000.0001 xe11        b86a.97d1.24d1      Up      9          L1   IS-IS

R1#show clns is-neighbors
```

```
Tag 1:  VRF : default
System Id      Interface   State  Type Priority  Circuit Id
0000.0000.0002 xe11        Up     L1   64        0000.0000.0001.01

R2#show clns is-neighbors

Tag 1:  VRF : default
System Id      Interface   State  Type Priority  Circuit Id
0000.0000.0001 xe11        Up     L1   64        0000.0000.0001.01

R1#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
2.2.2.2                  xe11       Passive   OPERATIONAL   30    00:08:08

R1#show ldp adjacency
Remote-Address  Local-Address   Mode     Intf-Name  Holdtime   LDP-Identifier
10.10.10.2      10.10.10.1      Interface     xe11        15         2.2.2.2:0

R2#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
1.1.1.1                  xe11       Active    OPERATIONAL   30    00:08:24

R2#show ldp adjacency
Remote-Address  Local-Address   Mode     Intf-Name  Holdtime   LDP-Identifier
10.10.10.1      10.10.10.2      Interface     xe11        15         1.1.1.1:0

R1#show isis interface xe11
xe11 is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x0000271C
    Local SNPA: b86a.97d1.24d1
    IP interface address:
      10.10.10.1/24
    IPv6 interface address:
      fe80::ba6a:97ff:fed1:24d1/64
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
    Number of active level-1 adjacencies: 1
    Level-1 LSP MTU: 1492
    Next IS-IS LAN Level-1 Hello in 792 milliseconds

R2#show isis interface xe11
xe11 is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x0000271B
    Local SNPA: 6cb9.c5cf.da69
    IP interface address:
      10.10.10.2/24
    IPv6 interface address:
      fe80::6eb9:c5ff:fecf:da69/64
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
    Number of active level-1 adjacencies: 1
```

```
    Level-1 LSP MTU: 1492
    Next IS-IS LAN Level-1 Hello in 1 seconds


R1#show isis database detail
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
0000.0000.0001.00-00* 0x00000002   0xB193        516               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  IP Address:   10.10.10.1
  Metric:   10         IS 0000.0000.0001.01
  Metric:   10         IP 10.10.10.0 255.255.255.0
  Metric:   10         IP 1.1.1.1 255.255.255.255
0000.0000.0001.01-00* 0x00000001   0x1FBD        516               0/0/0
  Metric:   0          IS 0000.0000.0001.00
  Metric:   0          IS 0000.0000.0002.00
0000.0000.0002.00-00  0x00000002   0x84BA        519               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  IP Address:   10.10.10.2
  Metric:   10         IS 0000.0000.0001.01
  Metric:   10         IP 10.10.10.0 255.255.255.0
  Metric:   10         IP 2.2.2.2 255.255.255.255

R2#show isis database detail
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
0000.0000.0001.00-00  0x00000002   0xB193        521               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  IP Address:   10.10.10.1
  Metric:   10         IS 0000.0000.0001.01
  Metric:   10         IP 10.10.10.0 255.255.255.0
  Metric:   10         IP 1.1.1.1 255.255.255.255
0000.0000.0001.01-00  0x00000001   0x1FBD        521               0/0/0
  Metric:   0          IS 0000.0000.0001.00
  Metric:   0          IS 0000.0000.0002.00
0000.0000.0002.00-00* 0x00000002   0x84BA        526               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  IP Address:   10.10.10.2
  Metric:   10         IS 0000.0000.0001.01
  Metric:   10         IP 10.10.10.0 255.255.255.0
  Metric:   10         IP 2.2.2.2 255.255.255.255
```

LDP-IGP SYNC Configuration

Now that NSM, IS-IS and LDP are all enabled, the LDP-IGP synchronization can be configured.

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RTR1

`(config)#interface xe11`	Enter interface mode.
`(config-if)#mpls ldp-igp sync isis level-1 holddown-timer 700`	Configure LDP-IGP Synchronization for interface xe11 belonging to an IS-IS process with corresponding IS-IS level.700 seconds is the holddown-timer value for IGP to wait until LDP converges. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. **IS-IS:** This command is part of ISIS Process. **Default:** Mandatory configuration. No default option. Note: The holddown-timer Range is 1 to 2147483 seconds. If no holddown timer is configured, IGP waits indefinitely for LDP to Converge. Use the command mpls ldp-igp sync is-is <level-type> to configure without a holddown-timer.
`(config-if)#mpls ldp-igp sync-delay 55`	Set the time delay in seconds for the notification of LDP convergence to IGP. This is not applicable for notification of non-convergence. Range is 5 to 60 seconds. This command is optional. **LDP:** This command is part of LDP Process. **Default:** If not configured, the delay is 0 seconds.
`(config-if)#commit`	Commit the transaction.

LDP-IGP SYNC Configuration

Now that NSM, IS-IS and LDP are all enabled, the LDP-IGP synchronization can be configured.

RTR2

`(config)#interface xe11`	Enter interface mode.
`(config-if)#mpls ldp-igp sync isis level-1 holddown-timer 700`	Configure LDP-IGP Synchronization for interface xe11 belonging to an IS-IS process with corresponding IS-IS level.700 secs is the holddown-timer value for IGP to wait until LDP converges. The parameters level-1|level-2-only|level-1-2 identify the IS-IS instance level. The interface can be acting on any level, but sync is applicable only when it matches with the level given in IGP sync command. **IS-IS:** This command is part of IS-IS Process. **Default:** Mandatory configuration. No default option. Note: The holddown-timer Range is 1 to 2147483 seconds. If no holddown timer is configured, IGP waits indefinitely for LDP to Converge. Use command mpls ldp-igp sync is-is <level-type> to configure without a holddown-timer.

(config-if)#mpls ldp-igp sync-delay 55	Set the time delay in seconds for notification of LDP convergence to IGP. This is not applicable for notification of non-convergence. Range is 5 to 60 seconds. This command is optional. **LDP:** This command is part of LDP Process. **Default:** If not configured, the delay is 0 seconds.
(config-if)#commit	Commit the transaction.

RTR1 Validation

When LDP IGP SYNC is Configured with hold-down and sync-delay timer

```
R1#show isis interface xe11
xe11 is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x0000271C
    Local SNPA: b86a.97d1.24d1
    IP interface address:
      10.10.10.1/24
    IPv6 interface address:
      fe80::ba6a:97ff:fed1:24d1/64
    LDP-ISIS Sync Configured
      Holddown timer = 700 seconds, Remaining time = 0 seconds
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
    Number of active level-1 adjacencies: 1
    Level-1 LSP MTU: 1492
    Next IS-IS LAN Level-1 Hello in 420 milliseconds

R1#show mpls ldp igp sync
xe11 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 2.2.2.2
    Sync status: Achieved
    Delay timer: Configured, 55 seconds, Not Running
R1#
```

RTR2 Validation

```
R2#show  isis interface xe11
xe11 is up, line protocol is up
  Routing Protocol: IS-IS (1)
    Network Type: Broadcast
    Circuit Type: level-1
    Local circuit ID: 0x01
    Extended Local circuit ID: 0x0000271B
    Local SNPA: 6cb9.c5cf.da69
    IP interface address:
      10.10.10.2/24
    IPv6 interface address:
      fe80::6eb9:c5ff:fecf:da69/64
    LDP-ISIS Sync Configured
      Holddown timer = 700 seconds, Remaining time = 0 seconds
```

```
    Level-1 Metric: 10/10, Priority: 64, Circuit ID: 0000.0000.0001.01
    Number of active level-1 adjacencies: 1
    Level-1 LSP MTU: 1492
    Next IS-IS LAN Level-1 Hello in 4 seconds

R2#show mpls ldp igp sync
xe11 is up, line protocol is up
  LDP configured; LDP-IGP Synchronization enabled.
  Session IP Address : 1.1.1.1
    Sync status: Achieved
    Delay timer: Configured, 55 seconds, Not Running
```

CHAPTER 4 LDP-FRR Configuration

LDP Fast Re-route (FRR) is a technology which helps the router to reduce the MPLS traffic loss in cases of convergence during network failure. A router's convergence time is in general in the order of hundreds of milliseconds, but some applications may be very sensitive to data-loss. This technology helps the router to minimize the MPLS traffic loss by calculating and installing alternate backup paths prior to failure.

LDP FRR improves convergence in case of a single link or single node failure in the network. Convergence times will be in the order of 10s of milliseconds (Max convergence - 50 milliseconds). This is important to some application services (like VoIP) which are sensitive to traffic loss when running over the MPLS network.

Without FRR, link and/or node failures inside an MPLS LDP network result in traffic loss in the order of 100s of milliseconds. The reason for that is that LDP depends on the convergence of the underlying IGP (IS-IS sending LSPs/ OSPF sending LSAs in this case). Post IGP convergence, LDP itself needs to compute new primary Next-Hop Label Forwarding Entries (NHLFEs) for all affected Forwarding Equivalence Classes (FECs). Finally, the different Label Forwarding Information Bases (LFIBs) are updated.

When FRR is configured on a node, the node pre-computes primary NHLFEs for all FECs and in addition it will pre-compute backup NHLFEs for all FECs. The backup NHLFE corresponds to the label received for the same FEC from a Loop-Free Alternate (LFA) next-hop.

Note: This implementation requires either ISIS LFA or OSPF LFA and LDP IGP synchronization.

Topology

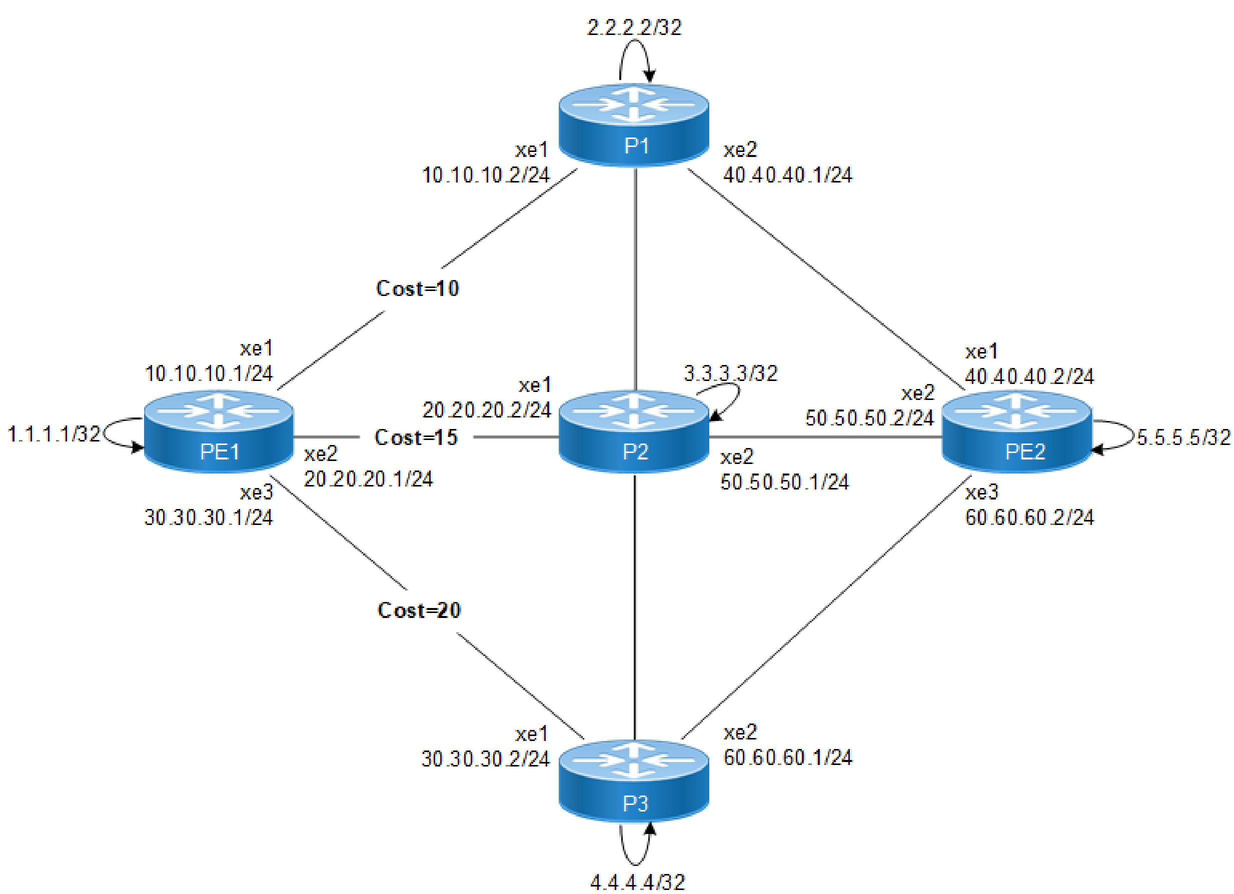

Figure 4-3: LDP-FRR Topology

LDP-FRR with OSPF as IGP Configuration

Below are the configurations and validations involving NSM, OSPF, LDP before configuring fast-reroute for IGP and LDP

PE1

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`(config-router)#transport-address ipv4 1.1.1.1 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 5.5.5.5`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.10.1/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 20.20.20.1/24`	Configure IPv4 address for xe2
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#ip ospf cost 15`	Assign ospf cost to the interface

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`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe3`	Enter interface mode.
`(config-if)#ip address 30.30.30.1/24`	Configure IPv4 address for xe3
`(config-if)#label-switching`	Enable label switching on interface xe3
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe3
`(config-if)#ip ospf cost 20`	Assign OSPF cost to the interface
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync OSPF to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 1`	Configure the routing process and specify the Process ID 100. The Process ID should be a unique positive integer identifying the routing process.
`(config)#ospf router-id 1.1.1.1`	Configure OSPF router-ID same as loopback interface IP address
`(config-router)#network 1.1.1.1/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 10.10.10.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 20.20.20.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 30.30.30.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#bfd all-interfaces`	Enable the OSPF enabled interfaces with bfd
`(config-if)#exit`	Exit interface mode.
`(config)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval
`(config)#commit`	Commit all the configurations

P1

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to 2.2.2.2/32
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2
`(config-router)#transport-address ipv4 2.2.2.2 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.10.2/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 40.40.40.1/24`	Configure IPv4 address for xe2
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 1`	Configure the routing process and specify the Process ID • The Process ID should be a unique positive integer identifying the routing process.

`(config)#ospf router-id 2.2.2.2`	Configure OSPF router-ID same as loopback interface IP address
`(config-router)#network 2.2.2.2/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#network 10.10.10.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#network 40.40.40.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#bfd all-interfaces`	Enable the OSPF enabled interfaces with bfd
`(config-if)#exit`	Exit interface mode.
`(config)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval
`(config)#commit`	Commit all the configurations

P2

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 3.3.3.3/32 secondary`	Set the IP address of the loopback interface
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 3.3.3.3`	Set the router ID to IP address 3.3.3.3
`(config-router)#transport-address ipv4 3.3.3.3 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 20.20.20.2/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 50.50.50.1/24`	Configure IPv4 address for xe2
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.

`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 1`	Configure the routing process and specify the Process ID • The Process ID should be a unique positive integer identifying the routing process.
`(config)#ospf router-id 3.3.3.3`	Configure OSPF router-ID same as loopback interface IP address
`(config-router)#network 3.3.3.3/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#network 20.20.20.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#network 50.50.50.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface
`(config-router)#bfd all-interfaces`	Enable the OSPF enabled interfaces with bfd
`(config-if)#exit`	Exit interface mode.
`(config)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval
`(config)#commit`	Commit all the configurations

P3

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 4.4.4.4/32 secondary`	Set the IP address of the loopback interface
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 4.4.4.4`	Set the router ID to IP address 4.4.4.4
`(config-router)#transport-address ipv4 4.4.4.4 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 30.30.30.2/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.

(config-if)#mpls ldp-igp sync ospf holddown-timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 60.60.60.1/24	Configure IPv4 address for xe2
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync ospf holddown-timer 500	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
(config-if)#exit	Exit interface mode
(config)#router ospf 1	Configure the routing process and specify the Process ID • The Process ID should be a unique positive integer identifying the routing process.
(config)#ospf router-id 4.4.4.4	Configure OSPF router-ID same as loopback interface IP address.
(config-router)#network 4.4.4.4/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 30.30.30.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 60.60.60.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

PE2

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 5.5.5.5/32 secondary	Set the IP address of the loopback interface to 5.5.5.5/32
(config-if)#exit	Exit interface mode.

`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 5.5.5.5`	Set the router ID to IP address 5.5.5.5
`(config-router)#transport-address ipv4 5.5.5.5 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 40.40.40.2/24`	Configure IPv4 address for xe1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 50.50.50.2/24`	Configure IPv4 address for xe2
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe3`	Enter interface mode.
`(config-if)#ip address 60.60.60.2/24`	Configure IPv4 address for xe3
`(config-if)#label-switching`	Enable label switching on interface xe3
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe3

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`(config-if)#mpls ldp-igp sync ospf holddown-timer 500`	Enable LDP-IGP Synchronization for xe1 belonging to an OSPF process.500 seconds is holddown-timer value for IGP to wait until LDP converges. OSPF: This command is part of OSPF Process. Note: Holddown-timer range is 1 to 2147483 seconds. If holddown timer is not configured, IGP waits indefinitely for LDP to converge. Use the command mpls ldp-igp sync ospf to configure without a holddown-timer.
`(config-if)#exit`	Exit interface mode
`(config)#router ospf 1`	Configure the routing process and specify the Process ID • The Process ID should be a unique positive integer identifying the routing process.
`(config)#ospf router-id 5.5.5.5`	Configure OSPF router-ID same as loopback interface IP address
`(config-router)#network 5.5.5.5/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 40.40.40.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 50.50.50.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 60.60.60.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#bfd all-interfaces`	Enable the OSPF enabled interfaces with bfd
`(config-if)#exit`	Exit interface mode.
`(config)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval
`(config)#commit`	Commit all the configurations

Validation

PE1

```
PE1#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/Backup      00:00:31    10.10.10.2      xe1                   0
3.3.3.3          1   Full/Backup      00:00:32    20.20.20.2      xe2                   0
4.4.4.4          1   Full/Backup      00:00:33    30.30.30.2      xe3                   0


PE1#show ip ospf interface brief
Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
lo           1     0.0.0.0         1          1     Loopback        0            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe1         1     0.0.0.0         4          10    DR              1            Up
```

```
Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
xe2        1     0.0.0.0         14         15    DR              1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
xe3        1     0.0.0.0         15         20    DR              1            Up

PE1#show ip ospf database

            OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)

                Router Link States (Area 0.0.0.0)

Link ID         ADV Router       Age      Seq#       CkSum  Link count
1.1.1.1         1.1.1.1           66      0x8000000e 0x5cf2 4
2.2.2.2         2.2.2.2           48      0x80000008 0x615f 3
3.3.3.3         3.3.3.3           48      0x80000008 0x64d7 3
4.4.4.4         4.4.4.4           44      0x80000008 0x6750 3
5.5.5.5         5.5.5.5           47      0x80000004 0xd65b 4

                Net Link States (Area 0.0.0.0)

Link ID         ADV Router       Age      Seq#       CkSum
10.10.10.1      1.1.1.1          249      0x80000001 0x9476
20.20.20.1      1.1.1.1          152      0x80000001 0x5d8b
30.30.30.1      1.1.1.1          106      0x80000001 0x26a0
40.40.40.1      2.2.2.2           55      0x80000001 0xf2a9
50.50.50.1      3.3.3.3           53      0x80000001 0x8de8
60.60.60.1      4.4.4.4           50      0x80000001 0x2828

                Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID         ADV Router      Age       Seq#       CkSum  Opaque ID
1.0.0.1         1.1.1.1          150      0x80000003 0x2cf8 1
1.0.0.1         2.2.2.2           54      0x80000002 0x32eb 1
1.0.0.1         3.3.3.3           51      0x80000003 0x34e0 1
1.0.0.1         4.4.4.4           48      0x80000003 0x38d4 1
1.0.0.1         5.5.5.5           54      0x80000001 0x40c6 1
1.0.0.8         4.4.4.4           48      0x80000001 0x7b37 8
1.0.0.8         5.5.5.5           49      0x80000001 0x7b32 8
1.0.0.10        1.1.1.1          236      0x80000002 0xda05 10
1.0.0.10        2.2.2.2          237      0x80000002 0x8360 10
1.0.0.12        3.3.3.3           46      0x80000002 0xc924 12
1.0.0.12        5.5.5.5           49      0x80000002 0xab39 12
1.0.0.22        2.2.2.2           46      0x80000002 0xdd46 22
1.0.0.22        5.5.5.5           47      0x80000002 0xa175 22
1.0.0.30        1.1.1.1          109      0x80000002 0x7614 30
1.0.0.30        3.3.3.3          110      0x80000002 0x424d 30
1.0.0.32        1.1.1.1           64      0x80000002 0xc680 32
1.0.0.32        4.4.4.4           65      0x80000002 0xb597 32
```

```
PE1#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
ospf            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 0
 Total number of IPv4 ECMP paths  : 0

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
xe0                 *10.12.49.172    up                    up
xe1                  unassigned      up                    up
xe1                  10.10.10.1      up                    up
xe3                  unassigned      up                    up
xe4                  unassigned      up                    up
xe5                  unassigned      up                    up
xe6                  unassigned      up                    up
xe7                  unassigned      up                    up
xe8                  unassigned      up                    up
xe9                  unassigned      up                    up
xe10                 unassigned      up                    up
xe11                 unassigned      up                    up
xe2                 20.20.20.1      up                    up
xe3                 30.30.30.1      up                    up
lo                    127.0.0.1       up                    up

PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                   xe2      Passive   OPERATIONAL   30    00:01:06
2.2.2.2                   xe1       Passive   OPERATIONAL   30    00:04:34
3.3.3.3                   xe2      Passive   OPERATIONAL   30    00:02:28
4.4.4.4                   xe3      Passive   OPERATIONAL   30    00:01:43

PE1#show ip route
```

```
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*           0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C            1.1.1.1/32 is directly connected, lo, 00:10:42
O            2.2.2.2/32 [110/11] via 10.10.10.2, xe1, 00:04:54
O            3.3.3.3/32 [110/13] via 10.10.10.2, xe1, 00:01:41
O            4.4.4.4/32 [110/13] via 10.10.10.2, xe1, 00:01:41
O            5.5.5.5/32 [110/12] via 10.10.10.2, xe1, 00:01:43
C            10.10.10.0/24 is directly connected, xe1, 00:08:51
C            10.12.49.0/24 is directly connected, xe0, 16:20:51
C            20.20.20.0/24 is directly connected, xe2, 00:08:51
C            30.30.30.0/24 is directly connected, xe3, 00:08:51
O            40.40.40.0/24 [110/11] via 10.10.10.2, xe1, 00:01:43
O            50.50.50.0/24 [110/12] via 10.10.10.2, xe1, 00:01:41
O            60.60.60.0/24 [110/12] via 10.10.10.2, xe1, 00:01:41
C            127.0.0.0/8 is directly connected, lo, 16:34:27

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Owner
0.0.0.0/0           10.12.49.1       xe0        kernel
1.1.1.1/32          0.0.0.0          lo          connected
2.2.2.2/32          10.10.10.2       xe1        ospf
3.3.3.3/32          10.10.10.2       xe1        ospf
4.4.4.4/32          10.10.10.2       xe1        ospf
5.5.5.5/32          10.10.10.2       xe1        ospf
10.10.10.0/24       0.0.0.0          xe1        connected
10.12.49.0/24       0.0.0.0          xe0        connected
20.20.20.0/24       0.0.0.0          xe2       connected
30.30.30.0/24       0.0.0.0          xe3       connected
40.40.40.0/24       10.10.10.2       xe1        ospf
50.50.50.0/24       10.10.10.2       xe1        ospf
60.60.60.0/24       10.10.10.2       xe1        ospf

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id    Pri   LSP-Type     Out-Label    Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -            Yes   LSP_DEFAULT  3            xe1         No    10.10.10.2
   L>   3.3.3.3/32         3         9         -            Yes   LSP_DEFAULT  25601        xe1         No    10.10.10.2
   L>   4.4.4.4/32         5         10        -            Yes   LSP_DEFAULT  25602        xe1         No    10.10.10.2
   L>   5.5.5.5/32         7         7         -            Yes   LSP_DEFAULT  25600        xe1         No    10.10.10.2
```

```
   L>   40.40.40.0/24       2         1         -           Yes   LSP_DEFAULT  3           xe1        No    10.10.10.2
   L>   50.50.50.0/24       4         11        -           Yes   LSP_DEFAULT  25612       xe1        No    10.10.10.2
   L>   60.60.60.0/24       6         8         -           Yes   LSP_DEFAULT  25609       xe1        No    10.10.10.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label    Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32          7         7         -           Yes   LSP_DEFAULT  25600        xe1        No    10.10.10.2
```

```
PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label    ELC    Nexthop Addr
1.1.1.1/32          E >     non-existent        none         No     connected
2.2.2.2/32          NL      4.4.4.4             25608        No     no nexthop
                    NL      3.3.3.3             25607        No     no nexthop
                    NL>     2.2.2.2             impl-null    No     10.10.10.2
3.3.3.3/32          NL      4.4.4.4             25609        No     no nexthop
                    NL>     2.2.2.2             25601        No     10.10.10.2
                    NL      3.3.3.3             impl-null    No     no nexthop
4.4.4.4/32          NL      3.3.3.3             25608        No     no nexthop
                    NL>     2.2.2.2             25602        No     10.10.10.2
                    NL      4.4.4.4             impl-null    No     no nexthop
5.5.5.5/32          NL      4.4.4.4             25610        No     no nexthop
                    NL>     2.2.2.2             25600        No     10.10.10.2
                    NL      3.3.3.3             25600        No     no nexthop
10.10.10.0/24       NL      4.4.4.4             25611        No     connected
                    NL      3.3.3.3             25610        No     connected
                    NL      2.2.2.2             impl-null    No     connected
                    E >     non-existent        none         No     connected
10.12.49.0/24       NL      4.4.4.4             impl-null    No     connected
                    NL      3.3.3.3             impl-null    No     connected
                    NL      2.2.2.2             impl-null    No     connected
                    E >     non-existent        none         No     connected
20.20.20.0/24       NL      4.4.4.4             25612        No     connected
                    NL      2.2.2.2             25610        No     connected
                    NL      3.3.3.3             impl-null    No     connected
                    E >     non-existent        none         No     connected
30.30.30.0/24       NL      3.3.3.3             25611        No     connected
                    NL      2.2.2.2             25611        No     connected
                    NL      4.4.4.4             impl-null    No     connected
                    E >     non-existent        none         No     connected
40.40.40.0/24       NL      4.4.4.4             25613        No     no nexthop
                    NL      3.3.3.3             25612        No     no nexthop
                    NL>     2.2.2.2             impl-null    No     10.10.10.2
50.50.50.0/24       NL      4.4.4.4             25614        No     no nexthop
                    NL>     2.2.2.2             25612        No     10.10.10.2
                    NL      3.3.3.3             impl-null    No     no nexthop
60.60.60.0/24       NL>     2.2.2.2             25609        No     10.10.10.2
```

```
                    NL      3.3.3.3             25609      No     no nexthop
                    NL      4.4.4.4             impl-null  No     no nexthop

PE1#show ldp downstream
gSession peer 5.5.5.5:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
Session peer 2.2.2.2:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
  50.50.50.0/24       10.10.10.2       Established      25612        0
  30.30.30.0/24       connected        Established      25611        0
  20.20.20.0/24       connected        Established      25610        0
  4.4.4.4/32          10.10.10.2       Established      25602        0
  3.3.3.3/32          10.10.10.2       Established      25601        0
  60.60.60.0/24       10.10.10.2       Established      25609        0
  5.5.5.5/32          10.10.10.2       Established      25600        0
  40.40.40.0/24       10.10.10.2       Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  10.10.10.0/24       connected        Established      impl-null    0
  2.2.2.2/32          10.10.10.2       Established      impl-null    0
Session peer 3.3.3.3:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
  40.40.40.0/24       connected        Established      25612        0
  30.30.30.0/24       connected        Established      25611        0
  10.10.10.0/24       connected        Established      25610        0
  4.4.4.4/32          connected        Established      25608        0
  2.2.2.2/32          connected        Established      25607        0
  60.60.60.0/24       connected        Established      25609        0
  5.5.5.5/32          connected        Established      25600        0
  50.50.50.0/24       connected        Established      impl-null    0
  20.20.20.0/24       connected        Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  3.3.3.3/32          connected        Established      impl-null    0
Session peer 4.4.4.4:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
  50.50.50.0/24       connected        Established      25614        0
  40.40.40.0/24       connected        Established      25613        0
  20.20.20.0/24       connected        Established      25612        0
  10.10.10.0/24       connected        Established      25611        0
  5.5.5.5/32          connected        Established      25610        0
  3.3.3.3/32          connected        Established      25609        0
  2.2.2.2/32          connected        Established      25608        0
  60.60.60.0/24       connected        Established      impl-null    0
  30.30.30.0/24       connected        Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  4.4.4.4/32          connected        Established      impl-null    0

PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
  1.1.1.1/32          connected        Established      none         0           None
```

```
  2.2.2.2/32          connected        Established      25608        0
  2.2.2.2/32          connected        Established      25607        0
  2.2.2.2/32          10.10.10.2       Established      impl-null    0
  3.3.3.3/32          connected        Established      25609        0
  3.3.3.3/32          10.10.10.2       Established      25601        0
  3.3.3.3/32          connected        Established      impl-null    0
  4.4.4.4/32          connected        Established      25608        0
  4.4.4.4/32          10.10.10.2       Established      25602        0
  4.4.4.4/32          connected        Established      impl-null    0
  5.5.5.5/32          connected        Established      25610        0
  5.5.5.5/32          10.10.10.2       Established      25600        0
  5.5.5.5/32          connected        Established      25600        0
  10.10.10.0/24       connected        Established      25611        0
  10.10.10.0/24       connected        Established      25610        0
  10.10.10.0/24       connected        Established      impl-null    0
  10.10.10.0/24       connected        Established      none         0            None
  10.12.49.0/24       connected        Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  10.12.49.0/24       connected        Established      none         0            None
  20.20.20.0/24       connected        Established      25612        0
  20.20.20.0/24       connected        Established      25610        0
  20.20.20.0/24       connected        Established      impl-null    0
  20.20.20.0/24       connected        Established      none         0            None
  30.30.30.0/24       connected        Established      25611        0
  30.30.30.0/24       connected        Established      25611        0
  30.30.30.0/24       connected        Established      impl-null    0
  30.30.30.0/24       connected        Established      none         0            None
  40.40.40.0/24       connected        Established      25613        0
  40.40.40.0/24       connected        Established      25612        0
  40.40.40.0/24       10.10.10.2       Established      impl-null    0
  50.50.50.0/24       connected        Established      25614        0
  50.50.50.0/24       10.10.10.2       Established      25612        0
  50.50.50.0/24       connected        Established      impl-null    0
  60.60.60.0/24       10.10.10.2       Established      25609        0
  60.60.60.0/24       connected        Established      25609        0
  60.60.60.0/24       connected        Established      impl-null    0

UPSTREAM LSP :
  FEC                 State            Label        Req.ID       Attr
  1.1.1.1/32          Established      impl-null    0            None
  1.1.1.1/32          Established      impl-null    0            None
  1.1.1.1/32          Established      impl-null    0            None
  2.2.2.2/32          Established      25602        0            None
  2.2.2.2/32          Established      25608        0            None
  3.3.3.3/32          Established      25614        0            None
  3.3.3.3/32          Established      25609        0            None
  3.3.3.3/32          Established      25609        0            None
  4.4.4.4/32          Established      25605        0            None
  4.4.4.4/32          Established      25615        0            None
```

```
  4.4.4.4/32          Established      25605       0           None
  5.5.5.5/32          Established      25606       0           None
  5.5.5.5/32          Established      25613       0           None
  5.5.5.5/32          Established      25613       0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  40.40.40.0/24       Established      25603       0           None
  40.40.40.0/24       Established      25610       0           None
  50.50.50.0/24       Established      25616       0           None
  50.50.50.0/24       Established      25611       0           None
  50.50.50.0/24       Established      25611       0           None
  60.60.60.0/24       Established      25607       0           None
  60.60.60.0/24       Established      25612       0           None
  60.60.60.0/24       Established      25612       0           None
  60.60.60.0/24       Established      25607       0           None

PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC                 Nexthop Addr     State             Label       Req.ID      Attr
  1.1.1.1/32          connected        Established       none        0           None
  2.2.2.2/32          connected        Established       25608       0
  2.2.2.2/32          connected        Established       25607       0
  2.2.2.2/32          10.10.10.2       Established       impl-null   0
  3.3.3.3/32          connected        Established       25609       0
  3.3.3.3/32          10.10.10.2       Established       25601       0
  3.3.3.3/32          connected        Established       impl-null   0
  4.4.4.4/32          connected        Established       25608       0
  4.4.4.4/32          10.10.10.2       Established       25602       0
  4.4.4.4/32          connected        Established       impl-null   0
  5.5.5.5/32          connected        Established       25610       0
  5.5.5.5/32          10.10.10.2       Established       25600       0
  5.5.5.5/32          connected        Established       25600       0
  10.10.10.0/24       connected        Established       25611       0
  10.10.10.0/24       connected        Established       25610       0
  10.10.10.0/24       connected        Established       impl-null   0
  10.10.10.0/24       connected        Established       none        0           None
  10.12.49.0/24       connected        Established       impl-null   0
  10.12.49.0/24       connected        Established       impl-null   0
  10.12.49.0/24       connected        Established       impl-null   0
  10.12.49.0/24       connected        Established       none        0           None
```

```
  20.20.20.0/24       connected        Established      25612       0
  20.20.20.0/24       connected        Established      25610       0
  20.20.20.0/24       connected        Established      impl-null   0
  20.20.20.0/24       connected        Established      none        0           None
  30.30.30.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      impl-null   0
  30.30.30.0/24       connected        Established      none        0           None
  40.40.40.0/24       connected        Established      25613       0
  40.40.40.0/24       connected        Established      25612       0
  40.40.40.0/24       10.10.10.2       Established      impl-null   0
  50.50.50.0/24       connected        Established      25614       0
  50.50.50.0/24       10.10.10.2       Established      25612       0
  50.50.50.0/24       connected        Established      impl-null   0
  60.60.60.0/24       10.10.10.2       Established      25609       0
  60.60.60.0/24       connected        Established      25609       0
  60.60.60.0/24       connected        Established      impl-null   0

UPSTREAM LSP :
  FEC                 State            Label       Req.ID      Attr
  1.1.1.1/32          Established      impl-null   0           None
  1.1.1.1/32          Established      impl-null   0           None
  1.1.1.1/32          Established      impl-null   0           None
  2.2.2.2/32          Established      25602       0           None
  2.2.2.2/32          Established      25608       0           None
  3.3.3.3/32          Established      25614       0           None
  3.3.3.3/32          Established      25609       0           None
  3.3.3.3/32          Established      25609       0           None
  4.4.4.4/32          Established      25605       0           None
  4.4.4.4/32          Established      25615       0           None
  4.4.4.4/32          Established      25605       0           None
  5.5.5.5/32          Established      25606       0           None
  5.5.5.5/32          Established      25613       0           None
  5.5.5.5/32          Established      25613       0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  40.40.40.0/24       Established      25603       0           None
  40.40.40.0/24       Established      25610       0           None
  50.50.50.0/24       Established      25616       0           None
  50.50.50.0/24       Established      25611       0           None
```

```
  50.50.50.0/24       Established      25611       0           None
  60.60.60.0/24       Established      25607       0           None
  60.60.60.0/24       Established      25612       0           None
  60.60.60.0/24       Established      25612       0           None
  60.60.60.0/24       Established      25607       0           None

PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NL>     2.2.2.2             25600       No    10.10.10.2
                    NL      3.3.3.3             25600       No    no nexthop

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe1, out label: 25602
    Nexthop addr: 10.10.10.2        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
```

```
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 8, op code: Push


PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
```

```
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push


PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF       Nexthop              pri    LSP-
Type
   L>   2.2.2.2/32        9           25608       3           N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   4.4.4.4/32        6           25605       25602       N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   2.2.2.2/32        3           25602       3           N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   40.40.40.0/24     4           25603       3           N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   5.5.5.5/32        7           25606       25600       N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   60.60.60.0/24     8           25607       25609       N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   60.60.60.0/24      13           25612       25609       N/A        xe1            10.10.10.2            Yes
LSP_DEFAULT
   L>   40.40.40.0/24     11          25610       3           N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   3.3.3.3/32        10          25609       25601       N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   50.50.50.0/24      12           25611       25612       N/A        xe1            10.10.10.2            Yes
LSP_DEFAULT
   L>   3.3.3.3/32        15          25614       25601       N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   5.5.5.5/32        14          25613       25600       N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   4.4.4.4/32        16          25615       25602       N/A        xe1            10.10.10.2            Yes    LSP_DEFAULT
   L>   50.50.50.0/24      17           25616       25612       N/A        xe1            10.10.10.2            Yes
LSP_DEFAULT
```

PE2

```
PE2#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2           1   Full/DR        00:00:36    40.40.40.1      xe1                 0
3.3.3.3           1   Full/DR        00:00:37    50.50.50.1      xe2                 0
4.4.4.4           1   Full/DR        00:00:31    60.60.60.1      xe3                 0

PE2#show ip ospf interface brief
Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
lo            1     0.0.0.0         1          1     Loopback        0            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
xe3          1     0.0.0.0         3          1     Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
xe2          1     0.0.0.0         5          1     Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
xe1          1     0.0.0.0         10         1     Backup          1            Up

PE2#show ip ospf database
```

```
            OSPF Router with ID (5.5.5.5) (Process ID 1 VRF default)

                Router Link States (Area 0.0.0.0)

Link ID         ADV Router       Age     Seq#       CkSum  Link count
1.1.1.1         1.1.1.1          650     0x8000000e 0x5cf2 4
2.2.2.2         2.2.2.2          630     0x80000008 0x615f 3
3.3.3.3         3.3.3.3          631     0x80000008 0x64d7 3
4.4.4.4         4.4.4.4          627     0x80000008 0x6750 3
5.5.5.5         5.5.5.5          628     0x80000004 0xd65b 4

                Net Link States (Area 0.0.0.0)

Link ID         ADV Router       Age     Seq#       CkSum
10.10.10.1      1.1.1.1          833     0x80000001 0x9476
20.20.20.1      1.1.1.1          736     0x80000001 0x5d8b
30.30.30.1      1.1.1.1          690     0x80000001 0x26a0
40.40.40.1      2.2.2.2          637     0x80000001 0xf2a9
50.50.50.1      3.3.3.3          636     0x80000001 0x8de8
60.60.60.1      4.4.4.4          632     0x80000001 0x2828

                Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID         ADV Router      Age      Seq#       CkSum  Opaque ID
1.0.0.1         1.1.1.1          734     0x80000003 0x2cf8 1
1.0.0.1         2.2.2.2          638     0x80000002 0x32eb 1
1.0.0.1         3.3.3.3          634     0x80000003 0x34e0 1
1.0.0.1         4.4.4.4          630     0x80000003 0x38d4 1
1.0.0.1         5.5.5.5          634     0x80000001 0x40c6 1
1.0.0.8         4.4.4.4          630     0x80000001 0x7b37 8
1.0.0.8         5.5.5.5          629     0x80000001 0x7b32 8
1.0.0.10        1.1.1.1          819     0x80000002 0xda05 10
1.0.0.10        2.2.2.2          818     0x80000002 0x8360 10
1.0.0.12        3.3.3.3          629     0x80000002 0xc924 12
1.0.0.12        5.5.5.5          629     0x80000002 0xab39 12
1.0.0.22        2.2.2.2          628     0x80000002 0xdd46 22
1.0.0.22        5.5.5.5          627     0x80000002 0xa175 22
1.0.0.30        1.1.1.1          693     0x80000002 0x7614 30
1.0.0.30        3.3.3.3          694     0x80000002 0x424d 30
1.0.0.32        1.1.1.1          648     0x80000002 0xc680 32
1.0.0.32        4.4.4.4          649     0x80000002 0xb597 32
PE2#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 16
```

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```
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
ospf            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 1
 Total number of IPv4 ECMP paths  : 3
 Number of routes with  3 ECMP paths: 1

PE2#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
xe0                 *10.12.49.174    up                    up
xe3                  60.60.60.2      up                    up
xe2                  unassigned      up                    up
xe2                  50.50.50.2      up                    up
xe4                  unassigned      up                    up
xe5                  unassigned      up                    up
xe6                  unassigned      up                    up
xe7                  unassigned      up                    up
xe1                  40.40.40.2      up                    up
xe9                  unassigned      up                    up
xe30                 unassigned      up                    up
xe31                 unassigned      up                    up
xe32                 unassigned      up                    up
xe33                 unassigned      up                    up
lo                    127.0.0.1       up                    up

PE2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
1.1.1.1                   xe1       Active    OPERATIONAL   30    00:10:40
2.2.2.2                   xe1       Active    OPERATIONAL   30    00:10:58
3.3.3.3                   xe2       Active    OPERATIONAL   30    00:10:58
4.4.4.4                   xe3       Active    OPERATIONAL   30    00:10:59

PE2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default
```

```
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*          0.0.0.0/0 [0/0] via 10.12.49.1, xe0
O           1.1.1.1/32 [110/3] via 60.60.60.1, xe3, 00:11:10
                       [110/3] via 40.40.40.1, xe1
                       [110/3] via 50.50.50.1, xe2
O           2.2.2.2/32 [110/2] via 40.40.40.1, xe1, 00:11:04
O           3.3.3.3/32 [110/2] via 50.50.50.1, xe2, 00:11:04
O           4.4.4.4/32 [110/2] via 60.60.60.1, xe3, 00:11:10
C           5.5.5.5/32 is directly connected, lo, 00:11:16
O           10.10.10.0/24 [110/2] via 40.40.40.1, xe1, 00:11:04
C           10.12.49.0/24 is directly connected, xe0, 16:28:18
O           20.20.20.0/24 [110/2] via 50.50.50.1, xe2, 00:11:04
O           30.30.30.0/24 [110/2] via 60.60.60.1, xe3, 00:11:10
C           40.40.40.0/24 is directly connected, xe1, 00:11:16
C           50.50.50.0/24 is directly connected, xe2, 00:11:16
C           60.60.60.0/24 is directly connected, xe3, 00:11:16
C           127.0.0.0/8 is directly connected, lo, 16:43:24

PE2#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Owner
0.0.0.0/0           10.12.49.1       xe0        kernel
1.1.1.1/32          50.50.50.1       xe2        ospf
                    40.40.40.1       xe1        ospf
                    60.60.60.1       xe3        ospf
2.2.2.2/32          40.40.40.1       xe1        ospf
3.3.3.3/32          50.50.50.1       xe2        ospf
4.4.4.4/32          60.60.60.1       xe3        ospf
5.5.5.5/32          0.0.0.0          lo          connected
10.10.10.0/24       40.40.40.1       xe1        ospf
10.12.49.0/24       0.0.0.0          xe0        connected
20.20.20.0/24       50.50.50.1       xe2        ospf
30.30.30.0/24       60.60.60.1       xe3        ospf
40.40.40.0/24       0.0.0.0          xe1        connected
50.50.50.0/24       0.0.0.0          xe2        connected
60.60.60.0/24       0.0.0.0          xe3        connected

PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         1         1         -          Yes   LSP_DEFAULT  25601
xe2        No    50.50.50.1
                                    5         -          Yes   LSP_DEFAULT  25603
xe1        No    40.40.40.1
```

```
                                9        -          Yes   LSP_DEFAULT  25600
xe3        No    60.60.60.1
   L>   2.2.2.2/32         6        6        -          Yes   LSP_DEFAULT  3
xe1        No    40.40.40.1
   L>   3.3.3.3/32         2        2        -          Yes   LSP_DEFAULT  3
xe2        No    50.50.50.1
   L>   4.4.4.4/32         3        10       -          Yes   LSP_DEFAULT  3
xe3        No    60.60.60.1
   L>   10.10.10.0/24      7        6        -          Yes   LSP_DEFAULT  3
xe1        No    40.40.40.1
   L>   20.20.20.0/24      4        2        -          Yes   LSP_DEFAULT  3
xe2        No    50.50.50.1
   L>   30.30.30.0/24      5        10       -          Yes   LSP_DEFAULT  3
xe3        No    60.60.60.1

PE2#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop

PE2#show mpls forwarding-table 1.1.1.1/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         1        1        -          Yes   LSP_DEFAULT  25601
xe2        No    50.50.50.1
                                5        -          Yes   LSP_DEFAULT  25603
xe1        No    40.40.40.1
                                9        -          Yes   LSP_DEFAULT  25600
xe3        No    60.60.60.1

PE2#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Owner
0.0.0.0/0           10.12.49.1       xe0        kernel
1.1.1.1/32          50.50.50.1       xe2        ospf
                    40.40.40.1       xe1        ospf
                    60.60.60.1       xe3        ospf
2.2.2.2/32          40.40.40.1       xe1        ospf
3.3.3.3/32          50.50.50.1       xe2        ospf
4.4.4.4/32          60.60.60.1       xe3        ospf
5.5.5.5/32          0.0.0.0          lo          connected
10.10.10.0/24       40.40.40.1       xe1        ospf
10.12.49.0/24       0.0.0.0          xe0        connected
20.20.20.0/24       50.50.50.1       xe2        ospf
30.30.30.0/24       60.60.60.1       xe3        ospf
```

```
40.40.40.0/24       0.0.0.0         xe1       connected
50.50.50.0/24       0.0.0.0         xe2       connected
60.60.60.0/24       0.0.0.0         xe3       connected
PE2#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          NL>     2.2.2.2             25603       No    40.40.40.1
                    NL>     3.3.3.3             25601       No    50.50.50.1
                    NL>     4.4.4.4             25600       No    60.60.60.1
2.2.2.2/32          NL>     2.2.2.2             impl-null   No    40.40.40.1
3.3.3.3/32          NL>     3.3.3.3             impl-null   No    50.50.50.1
4.4.4.4/32          NL>     4.4.4.4             impl-null   No    60.60.60.1
5.5.5.5/32          E >     non-existent        none        No    connected
10.10.10.0/24       NL>     2.2.2.2             impl-null   No    40.40.40.1
10.12.49.0/24       NL      2.2.2.2             impl-null   No    connected
                    NL      3.3.3.3             impl-null   No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL>     3.3.3.3             impl-null   No    50.50.50.1
30.30.30.0/24       NL>     4.4.4.4             impl-null   No    60.60.60.1
40.40.40.0/24       NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
50.50.50.0/24       NL      3.3.3.3             impl-null   No    connected
                    E >     non-existent        none        No    connected
60.60.60.0/24       NL      4.4.4.4             impl-null   No    connected
                    E >     non-existent        none        No    connected

PE2#show ldp downstream
Session peer 1.1.1.1:
  FEC                 Nexthop Addr     State            Label        Req.ID       Attr
Session peer 2.2.2.2:
  FEC                 Nexthop Addr     State            Label        Req.ID       Attr
  40.40.40.0/24       connected        Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  10.10.10.0/24       40.40.40.1       Established      impl-null    0
  2.2.2.2/32          40.40.40.1       Established      impl-null    0
  1.1.1.1/32          40.40.40.1       Established      25603        0
Session peer 3.3.3.3:
  FEC                 Nexthop Addr     State            Label        Req.ID       Attr
  50.50.50.0/24       connected        Established      impl-null    0
  20.20.20.0/24       50.50.50.1       Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  3.3.3.3/32          50.50.50.1       Established      impl-null    0
  1.1.1.1/32          50.50.50.1       Established      25601        0
Session peer 4.4.4.4:
  FEC                 Nexthop Addr     State            Label        Req.ID       Attr
  60.60.60.0/24       connected        Established      impl-null    0
  30.30.30.0/24       60.60.60.1       Established      impl-null    0
```

```
  10.12.49.0/24       connected         Established       impl-null   0
  4.4.4.4/32          60.60.60.1        Established       impl-null   0
  1.1.1.1/32          60.60.60.1        Established       25600       0

PE2#show ldp lsp
DOWNSTREAM LSP :
  FEC                 Nexthop Addr      State             Label       Req.ID       Attr
  1.1.1.1/32          40.40.40.1        Established       25603       0
  1.1.1.1/32          50.50.50.1        Established       25601       0
  1.1.1.1/32          60.60.60.1        Established       25600       0
  2.2.2.2/32          40.40.40.1        Established       impl-null   0
  3.3.3.3/32          50.50.50.1        Established       impl-null   0
  4.4.4.4/32          60.60.60.1        Established       impl-null   0
  5.5.5.5/32          connected         Established       none        0            None
  10.10.10.0/24       40.40.40.1        Established       impl-null   0
  10.12.49.0/24       connected         Established       impl-null   0
  10.12.49.0/24       connected         Established       impl-null   0
  10.12.49.0/24       connected         Established       impl-null   0
  10.12.49.0/24       connected         Established       none        0            None
  20.20.20.0/24       50.50.50.1        Established       impl-null   0
  30.30.30.0/24       60.60.60.1        Established       impl-null   0
  40.40.40.0/24       connected         Established       impl-null   0
  40.40.40.0/24       connected         Established       none        0            None
  50.50.50.0/24       connected         Established       impl-null   0
  50.50.50.0/24       connected         Established       none        0            None
  60.60.60.0/24       connected         Established       impl-null   0
  60.60.60.0/24       connected         Established       none        0            None

UPSTREAM LSP :
  FEC                 State             Label        Req.ID       Attr
  2.2.2.2/32          Established       25607        0            None
  2.2.2.2/32          Established       25601        0            None
  3.3.3.3/32          Established       25602        0            None
  3.3.3.3/32          Established       25609        0            None
  4.4.4.4/32          Established       25611        0            None
  4.4.4.4/32          Established       25612        0            None
  5.5.5.5/32          Established       impl-null    0            None
  5.5.5.5/32          Established       impl-null    0            None
  5.5.5.5/32          Established       impl-null    0            None
  10.10.10.0/24       Established       25608        0            None
  10.10.10.0/24       Established       25604        0            None
  10.12.49.0/24       Established       impl-null    0            None
  10.12.49.0/24       Established       impl-null    0            None
  10.12.49.0/24       Established       impl-null    0            None
  20.20.20.0/24       Established       25605        0            None
  20.20.20.0/24       Established       25610        0            None
  30.30.30.0/24       Established       25613        0            None
  30.30.30.0/24       Established       25614        0            None
  40.40.40.0/24       Established       impl-null    0            None
  40.40.40.0/24       Established       impl-null    0            None
```

```
  40.40.40.0/24       Established      impl-null   0           None
  50.50.50.0/24       Established      impl-null   0           None
  50.50.50.0/24       Established      impl-null   0           None
  50.50.50.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None

PE2#show ldp fec prefix 1.1.1.1/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          NL>     2.2.2.2             25603       No    40.40.40.1
                    NL>     3.3.3.3             25601       No    50.50.50.1
                    NL>     4.4.4.4             25600       No    60.60.60.1

PE2#show router-id
Name: management
 Router ID is not set
Name: default
 Router ID: 10.12.49.174 (automatic)

PE2#show mpls ftn-table
 Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe2, out label: 25601
    Nexthop addr: 50.50.50.1        cross connect ix: 2, op code: Push

     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25603
    Nexthop addr: 40.40.40.1        cross connect ix: 2, op code: Push

     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe3, out label: 25600
    Nexthop addr: 60.60.60.1        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 6, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
```

```
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 40.40.40.1        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 50.50.50.1        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe3, out label: 3
    Nexthop addr: 60.60.60.1        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 10.10.10.0/24, id: 7, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 40.40.40.1        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 20.20.20.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 50.50.50.1        cross connect ix: 3, op code: Push
```

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```
 Primary FTN entry with FEC: 30.30.30.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe3, out label: 3
    Nexthop addr: 60.60.60.1        cross connect ix: 1, op code: Push


PE2#show mpls ftn-table 1.1.1.1/32
 Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe2, out label: 25601
    Nexthop addr: 50.50.50.1        cross connect ix: 2, op code: Push

     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25603
    Nexthop addr: 40.40.40.1        cross connect ix: 2, op code: Push

     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe3, out label: 25600
    Nexthop addr: 60.60.60.1        cross connect ix: 2, op code: Push
```

```
PE2#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF       Nexthop                pri    LSP-
Type
   L>   3.3.3.3/32        10          25609       3          N/A       xe2            50.50.50.1            Yes    LSP_DEFAULT
   L>   20.20.20.0/24     6           25605       3          N/A       xe2            50.50.50.1            Yes    LSP_DEFAULT
   L>   3.3.3.3/32        3           25602       3          N/A       xe2            50.50.50.1            Yes    LSP_DEFAULT
   L>   2.2.2.2/32        2           25601       3          N/A       xe1            40.40.40.1            Yes    LSP_DEFAULT
   L>   10.10.10.0/24     5           25604       3          N/A       xe1            40.40.40.1            Yes    LSP_DEFAULT
   L>   2.2.2.2/32        8           25607       3          N/A       xe1            40.40.40.1            Yes    LSP_DEFAULT
   L>   10.10.10.0/24     9           25608       3          N/A       xe1            40.40.40.1            Yes    LSP_DEFAULT
   L>   4.4.4.4/32        12          25611       3          N/A       xe3            60.60.60.1            Yes    LSP_DEFAULT
   L>   20.20.20.0/24     11          25610       3          N/A       xe2            50.50.50.1            Yes    LSP_DEFAULT
   L>   30.30.30.0/24     14          25613       3          N/A       xe3            60.60.60.1            Yes    LSP_DEFAULT
   L>   4.4.4.4/32        13          25612       3          N/A       xe3            60.60.60.1            Yes    LSP_DEFAULT
   L>   30.30.30.0/24     15          25614       3          N/A       xe3            60.60.60.1            Yes    LSP_DEFAULT
```

RTR1 - FRR Configuration

Now that NSM, OSPF and LDP are all configured, FRR for IGP and LDP can be enabled using below configurations.

`#configure terminal`	Enter configuration mode.
`(config)#router ospf 1`	Configure the routing process and specify the Process ID • The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#fast-reroute keep-all-paths`	Configure OSPF LFA-FRR to calculate the available backup path
`(config-router)#exit`	Exit router mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#fast-reroute`	Configure LDP LFA-FRR to calculate the available backup path
`(config-router)#exit`	Exit router mode.
`(config)#commit`	Commit all the configurations

Validation

```
PE1#show ip route fast-reroute
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p -
stale info, E - EVPN
       * - candidate default

IP Route Table for VRF "default"
O       2.2.2.2/32 [110/11] via 10.10.10.2, xe2, 00:38:00
                   [FRR-NH] via 20.20.20.2, xe12

O       3.3.3.3/32 [110/13] via 10.10.10.2, xe2, 00:34:47
                   [FRR-NH] via 20.20.20.2, xe12

O       4.4.4.4/32 [110/13] via 10.10.10.2, xe2, 00:34:47
                   [FRR-NH] via 20.20.20.2, xe12

O       5.5.5.5/32 [110/12] via 10.10.10.2, xe2, 00:34:49
                   [FRR-NH] via 20.20.20.2, xe12

O       40.40.40.0/24 [110/11] via 10.10.10.2, xe2, 00:34:49
                      [FRR-NH] via 20.20.20.2, xe12

O       50.50.50.0/24 [110/12] via 10.10.10.2, xe2, 00:34:47
                      [FRR-NH] via 20.20.20.2, xe12
```

```
O       60.60.60.0/24 [110/12] via 10.10.10.2, xe2, 00:34:47
                      [FRR-NH] via 20.20.20.2, xe12

PE1#show ip ospf route fast-reroute

OSPF process 1:
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       OSPF LFA attributes:
       P - Primary, SP - Secondary-Path, LP - Link Protecting,
       NP - Node Protecting, BID - Broadcast Link Protecting
       DP - Downstream Protecting

O  2.2.2.2/32 [11] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                         via 20.20.20.2, xe12, Area 0.0.0.0
                        Attributes: Metric: [18] ,SP ,BID ,DP
O  3.3.3.3/32 [13] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                         via 20.20.20.2, xe12, Area 0.0.0.0
                        Attributes: Metric: [16] ,SP ,NP ,BID ,DP
O  4.4.4.4/32 [13] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                         via 20.20.20.2, xe12, Area 0.0.0.0
                        Attributes: Metric: [18] ,SP ,NP ,BID ,DP
O  5.5.5.5/32 [12] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                         via 20.20.20.2, xe12, Area 0.0.0.0
                        Attributes: Metric: [17] ,SP ,NP ,BID ,DP
O  20.20.20.0/24 [13] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                            via 20.20.20.2, xe12, Area 0.0.0.0
                           Attributes: Metric: [16] ,SP ,NP ,BID ,DP
O  30.30.30.0/24 [13] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                            via 20.20.20.2, xe12, Area 0.0.0.0
                           Attributes: Metric: [18] ,SP ,NP ,BID ,DP
O  40.40.40.0/24 [11] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                            via 20.20.20.2, xe12, Area 0.0.0.0
                           Attributes: Metric: [17] ,SP ,NP ,BID ,DP
O  50.50.50.0/24 [12] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                            via 20.20.20.2, xe12, Area 0.0.0.0
                           Attributes: Metric: [16] ,SP ,NP ,BID ,DP
O  60.60.60.0/24 [12] via 10.10.10.2, xe2, Area 0.0.0.0
                        Backup path:
                            via 20.20.20.2, xe12, Area 0.0.0.0
```

```
                                   Attributes: Metric: [17] ,SP ,NP ,BID ,DP

PE1#show ldp routes
Prefix Addr          Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0            10.12.49.1       xe0        -                 -                kernel
1.1.1.1/32          0.0.0.0          lo          -                -                connected
2.2.2.2/32           10.10.10.2       xe2        20.20.20.2       xe12             ospf
3.3.3.3/32           10.10.10.2       xe2        20.20.20.2       xe12             ospf
4.4.4.4/32           10.10.10.2       xe2        20.20.20.2       xe12             ospf
5.5.5.5/32           10.10.10.2       xe2        20.20.20.2       xe12             ospf
10.10.10.0/24       0.0.0.0          xe2        -                -                connected
10.12.49.0/24       0.0.0.0          xe0        -                -                connected
20.20.20.0/24       0.0.0.0          xe12       -                -                connected
30.30.30.0/24       0.0.0.0          xe13       -                -                connected
40.40.40.0/24        10.10.10.2       xe2        20.20.20.2       xe12             ospf
50.50.50.0/24        10.10.10.2       xe2        20.20.20.2       xe12             ospf
60.60.60.0/24        10.10.10.2       xe2        20.20.20.2       xe12             ospf

PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                  Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32           E >     non-existent        none        No    connected
2.2.2.2/32           NL      4.4.4.4             25608       No    no nexthop
                     NLB>    3.3.3.3             25607       No    20.20.20.2
                     NLP>    2.2.2.2             impl-null   No    10.10.10.2
3.3.3.3/32           NL      4.4.4.4             25609       No    no nexthop
                     NLP>    2.2.2.2             25601       No    10.10.10.2
                     NLB>    3.3.3.3             impl-null   No    20.20.20.2
4.4.4.4/32           NLB>    3.3.3.3             25608       No    20.20.20.2
                     NLP>    2.2.2.2             25602       No    10.10.10.2
                     NL      4.4.4.4             impl-null   No    no nexthop
5.5.5.5/32           NL      4.4.4.4             25610       No    no nexthop
                     NLP>    2.2.2.2             25600       No    10.10.10.2
                     NLB>    3.3.3.3             25600       No    20.20.20.2
10.10.10.0/24        NL      4.4.4.4             25611       No    connected
                     NL      3.3.3.3             25610       No    connected
                     NL      2.2.2.2             impl-null   No    connected
                     E >     non-existent        none        No    connected
10.12.49.0/24        NL      4.4.4.4             impl-null   No    connected
                     NL      3.3.3.3             impl-null   No    connected
                     NL      2.2.2.2             impl-null   No    connected
                     E >     non-existent        none        No    connected
20.20.20.0/24        NL      4.4.4.4             25612       No    connected
                     NL      2.2.2.2             25610       No    connected
                     NL      3.3.3.3             impl-null   No    connected
                     E >     non-existent        none        No    connected
```

```
30.30.30.0/24       NL      3.3.3.3            25611       No    connected
                    NL      2.2.2.2            25611       No    connected
                    NL      4.4.4.4            impl-null   No    connected
                    E >     non-existent       none        No    connected
40.40.40.0/24       NL      4.4.4.4            25613       No    no nexthop
                    NLB>    3.3.3.3            25612       No    20.20.20.2
                    NLP>    2.2.2.2            impl-null   No    10.10.10.2
50.50.50.0/24       NL      4.4.4.4            25614       No    no nexthop
                    NLP>    2.2.2.2            25612       No    10.10.10.2
                    NLB>    3.3.3.3            impl-null   No    20.20.20.2
60.60.60.0/24       NLP>    2.2.2.2            25609       No    10.10.10.2
                    NLB>    3.3.3.3            25609       No    20.20.20.2
                    NL      4.4.4.4            impl-null   No    no nexthop
PE1#show ldp downstream
Codes: P - Primary route, B - Backup route
Session peer 5.5.5.5:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
Codes: P - Primary route, B - Backup route
Session peer 2.2.2.2:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
  50.50.50.0/24      10.10.10.2      Established     25612      0
P
   30.30.30.0/24       connected        Established      25611       0
   20.20.20.0/24       connected        Established      25610       0
  4.4.4.4/32        10.10.10.2      Established     25602      0
P
  3.3.3.3/32        10.10.10.2      Established     25601      0
P
  60.60.60.0/24      10.10.10.2      Established     25609      0
P
  5.5.5.5/32        10.10.10.2      Established     25600      0
P
  40.40.40.0/24      10.10.10.2      Established     impl-null   0
P
   10.12.49.0/24       connected        Established      impl-null   0
   10.10.10.0/24       connected        Established      impl-null   0
  2.2.2.2/32        10.10.10.2      Established     impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 3.3.3.3:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
   40.40.40.0/24       connected        Established      25612       0
  40.40.40.0/24      20.20.20.2      Established     25612      0
B
   30.30.30.0/24       connected        Established      25611       0
   10.10.10.0/24       connected        Established      25610       0
   4.4.4.4/32          connected        Established      25608       0
  4.4.4.4/32        20.20.20.2      Established     25608      0
B
   2.2.2.2/32          connected        Established      25607       0
```

```
  2.2.2.2/32        20.20.20.2     Established    25607     0
B
  60.60.60.0/24       connected       Established      25609       0
  60.60.60.0/24     20.20.20.2     Established    25609     0
B
  5.5.5.5/32          connected       Established      25600       0
  5.5.5.5/32        20.20.20.2     Established    25600     0
B
  50.50.50.0/24       connected       Established      impl-null   0
  50.50.50.0/24     20.20.20.2     Established    impl-null  0
B
  20.20.20.0/24       connected       Established      impl-null   0
  10.12.49.0/24       connected       Established      impl-null   0
  3.3.3.3/32          connected       Established      impl-null   0
  3.3.3.3/32        20.20.20.2     Established    impl-null  0
B
Codes: P - Primary route, B - Backup route
Session peer 4.4.4.4:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
  50.50.50.0/24       connected       Established      25614       0
  40.40.40.0/24       connected       Established      25613       0
  20.20.20.0/24       connected       Established      25612       0
  10.10.10.0/24       connected       Established      25611       0
  5.5.5.5/32          connected       Established      25610       0
  3.3.3.3/32          connected       Established      25609       0
  2.2.2.2/32          connected       Established      25608       0
  60.60.60.0/24       connected       Established      impl-null   0
  30.30.30.0/24       connected       Established      impl-null   0
  10.12.49.0/24       connected       Established      impl-null   0
  4.4.4.4/32          connected       Established      impl-null   0

PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
  1.1.1.1/32          connected       Established      none        0           None
  2.2.2.2/32          connected       Established      25608       0
  2.2.2.2/32          connected       Established      25607       0
  2.2.2.2/32        20.20.20.2     Established    25607     0
B
  2.2.2.2/32        10.10.10.2     Established    impl-null  0
P
  3.3.3.3/32          connected       Established      25609       0
  3.3.3.3/32        10.10.10.2     Established    25601     0
P
  3.3.3.3/32          connected       Established      impl-null   0
  3.3.3.3/32        20.20.20.2     Established    impl-null  0
B
  4.4.4.4/32          connected       Established      25608       0
  4.4.4.4/32        20.20.20.2     Established    25608     0
B
```

```
  4.4.4.4/32        10.10.10.2     Established    25602     0
P
  4.4.4.4/32          connected        Established      impl-null   0
  5.5.5.5/32          connected        Established      25610       0
  5.5.5.5/32        10.10.10.2     Established    25600     0
P
  5.5.5.5/32          connected        Established      25600       0
  5.5.5.5/32        20.20.20.2     Established    25600     0
B
  10.10.10.0/24       connected        Established      25611       0
  10.10.10.0/24       connected        Established      25610       0
  10.10.10.0/24       connected        Established      impl-null   0
  10.10.10.0/24       connected        Established      none        0           None
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      none        0           None
  20.20.20.0/24       connected        Established      25612       0
  20.20.20.0/24       connected        Established      25610       0
  20.20.20.0/24       connected        Established      impl-null   0
  20.20.20.0/24       connected        Established      none        0           None
  30.30.30.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      impl-null   0
  30.30.30.0/24       connected        Established      none        0           None
  40.40.40.0/24       connected        Established      25613       0
  40.40.40.0/24       connected        Established      25612       0
  40.40.40.0/24     20.20.20.2     Established    25612     0
B
  40.40.40.0/24     10.10.10.2     Established    impl-null  0
P
  50.50.50.0/24       connected        Established      25614       0
  50.50.50.0/24     10.10.10.2     Established    25612     0
P
  50.50.50.0/24       connected        Established      impl-null   0
  50.50.50.0/24     20.20.20.2     Established    impl-null  0
B
  60.60.60.0/24     10.10.10.2     Established    25609     0
P
  60.60.60.0/24       connected        Established      25609       0
  60.60.60.0/24     20.20.20.2     Established    25609     0
B
  60.60.60.0/24       connected        Established      impl-null   0

UPSTREAM LSP :
  FEC                 State             Label        Req.ID       Attr
  1.1.1.1/32          Established       impl-null    0            None
  1.1.1.1/32          Established       impl-null    0            None
  1.1.1.1/32          Established       impl-null    0            None
  2.2.2.2/32          Established       25608        0            None
  2.2.2.2/32          Established       25602        0            None
  2.2.2.2/32          Established       25608        0            None
```

```
  3.3.3.3/32          Established     25614      0           None
  3.3.3.3/32          Established     25609      0           None
  3.3.3.3/32          Established     25609      0           None
  4.4.4.4/32          Established     25615      0           None
  4.4.4.4/32          Established     25605      0           None
  4.4.4.4/32          Established     25615      0           None
  4.4.4.4/32          Established     25605      0           None
  5.5.5.5/32          Established     25606      0           None
  5.5.5.5/32          Established     25613      0           None
  5.5.5.5/32          Established     25613      0           None
  10.10.10.0/24       Established     impl-null  0           None
  10.10.10.0/24       Established     impl-null  0           None
  10.10.10.0/24       Established     impl-null  0           None
  10.12.49.0/24       Established     impl-null  0           None
  10.12.49.0/24       Established     impl-null  0           None
  10.12.49.0/24       Established     impl-null  0           None
  20.20.20.0/24       Established     impl-null  0           None
  20.20.20.0/24       Established     impl-null  0           None
  20.20.20.0/24       Established     impl-null  0           None
  30.30.30.0/24       Established     impl-null  0           None
  30.30.30.0/24       Established     impl-null  0           None
  30.30.30.0/24       Established     impl-null  0           None
  40.40.40.0/24       Established     25610      0           None
  40.40.40.0/24       Established     25603      0           None
  40.40.40.0/24       Established     25610      0           None
  50.50.50.0/24       Established     25616      0           None
  50.50.50.0/24       Established     25611      0           None
  50.50.50.0/24       Established     25611      0           None
  60.60.60.0/24       Established     25607      0           None
  60.60.60.0/24       Established     25612      0           None
  60.60.60.0/24       Established     25612      0           None
  60.60.60.0/24       Established     25607      0           None

PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NLP>    2.2.2.2             25600       No    10.10.10.2
                    NLB>    3.3.3.3             25600       No    20.20.20.2

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

```
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -           Yes   LSP_DEFAULT  3
xe2         No    10.10.10.2
                                     2         -           No    LSP_DEFAULT  25607
xe12        No    20.20.20.2
   L>   3.3.3.3/32         3         9         -           Yes   LSP_DEFAULT  25601
xe2         No    10.10.10.2
                                     3         -           No    LSP_DEFAULT  3
xe12        No    20.20.20.2
   L>   4.4.4.4/32         5         10        -           Yes   LSP_DEFAULT  25602
xe2         No    10.10.10.2
                                     4         -           No    LSP_DEFAULT  25608
xe12        No    20.20.20.2
   L>   5.5.5.5/32         7         7         -           Yes   LSP_DEFAULT  25600
xe2         No    10.10.10.2
                                     5         -           No    LSP_DEFAULT  25600
xe12        No    20.20.20.2
   L>   40.40.40.0/24      2         1         -           Yes   LSP_DEFAULT  3
xe2         No    10.10.10.2
                                     6         -           No    LSP_DEFAULT  25612
xe12        No    20.20.20.2
   L>   50.50.50.0/24      4         11        -           Yes   LSP_DEFAULT  25612
xe2         No    10.10.10.2
                                     3         -           No    LSP_DEFAULT  3
xe12        No    20.20.20.2
   L>   60.60.60.0/24      6         8         -           Yes   LSP_DEFAULT  25609
xe2         No    10.10.10.2
                                     12        -           No    LSP_DEFAULT  25609
xe12        No    20.20.20.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7         7         -           Yes   LSP_DEFAULT  25600
xe2         No    10.10.10.2
                                     5         -           No    LSP_DEFAULT  25600
xe12        No    20.20.20.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push
```

```
      Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 2
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe12, out label: 25607
    Nexthop addr: 20.20.20.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe2, out label: 25601
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push

      Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 3
       Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe12, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe2, out label: 25602
    Nexthop addr: 10.10.10.2        cross connect ix: 6, op code: Push

      Backup Cross connect ix: 5, in intf: - in label: 0  out-segment ix: 4
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe12, out label: 25608
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push

      Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 5
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe12, out label: 25600
```

```
    Nexthop addr: 20.20.20.2        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 9, in intf: - in label: 0  out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe12, out label: 25612
    Nexthop addr: 20.20.20.2        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe2, out label: 25612
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push

     Backup Cross connect ix: 11, in intf: - in label: 0  out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe12, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 8, op code: Push

     Backup Cross connect ix: 13, in intf: - in label: 0  out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe12, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 13, op code: Push
```

```
PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:391, pkts:5, TX bytes:411, Pushed pkts:5
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe12, out label: 25600
    Nexthop addr: 20.20.20.2        cross connect ix: 7, op code: Push


PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                  pri    LSP-
Type
   L>   2.2.2.2/32         9          25608       3           N/A        xe2
10.10.10.2               Yes    LSP_
DEFAULT
                                     25608       25607       N/A        xe12
20.20.20.2               No     LSP_
DEFAULT
   L>   4.4.4.4/32         6          25605       25602       N/A        xe2
10.10.10.2               Yes    LSP_
DEFAULT
   L>   2.2.2.2/32         3          25602       3           N/A        xe2
10.10.10.2               Yes    LSP_
DEFAULT
   L>   40.40.40.0/24      4          25603       3           N/A        xe2
10.10.10.2               Yes    LSP_
DEFAULT
   L>   5.5.5.5/32         7          25606       25600       N/A        xe2
10.10.10.2               Yes    LSP_
DEFAULT
   L>   60.60.60.0/24      8          25607       25609       N/A        xe2
10.10.10.2               Yes    LSP_
DEFAULT
   L>   60.60.60.0/24      13         25612       25609       N/A        xe2
10.10.10.2               Yes    LSP_
```

```
DEFAULT
                                  25612      25609      N/A        xe12
20.20.20.2            No     LSP_
DEFAULT
   L>   40.40.40.0/24     11          25610      3          N/A        xe2
10.10.10.2            Yes    LSP_
DEFAULT
                                  25610      25612      N/A        xe12
20.20.20.2            No     LSP_
DEFAULT
   L>   3.3.3.3/32        10          25609      25601      N/A        xe2
10.10.10.2            Yes    LSP_
DEFAULT
                                  25609      3          N/A        xe12
20.20.20.2            No     LSP_
DEFAULT
   L>   50.50.50.0/24     12          25611      25612      N/A        xe2
10.10.10.2            Yes    LSP_
DEFAULT
                                  25611      3          N/A        xe12
20.20.20.2            No     LSP_
DEFAULT
   L>   3.3.3.3/32        15          25614      25601      N/A        xe2
10.10.10.2            Yes    LSP_
DEFAULT
   L>   5.5.5.5/32        14          25613      25600      N/A        xe2
10.10.10.2            Yes    LSP_
DEFAULT
                                  25613      25600      N/A        xe12
20.20.20.2            No     LSP_
DEFAULT
   L>   4.4.4.4/32        16          25615      25602      N/A        xe2
10.10.10.2            Yes    LSP_
DEFAULT
                                  25615      25608      N/A        xe12
20.20.20.2            No     LSP_
DEFAULT
   L>   50.50.50.0/24     17          25616      25612      N/A        xe2
10.10.10.2            Yes    LSP_
DEFAULT

PE1#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2           1   Full/Backup      00:00:31    10.10.10.2      xe2                  0
3.3.3.3           1   Full/Backup      00:00:29    20.20.20.2      xe12                 0
4.4.4.4           1   Full/Backup      00:00:39    30.30.30.2      xe13                 0

PE1#show ip ospf interface brief
Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
lo            1     0.0.0.0         1          1     Loopback        0            Up
```

```
Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe2         1     0.0.0.0         4          10    DR              1           Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe12        1     0.0.0.0         14         15    DR              1           Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe13        1     0.0.0.0         15         20    DR              1           Up

PE1#show ip ospf database

            OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)

                Router Link States (Area 0.0.0.0)

Link ID         ADV Router       Age      Seq#       CkSum  Link count
1.1.1.1         1.1.1.1          473      0x8000000f 0x5af3 4
2.2.2.2         2.2.2.2          504      0x80000009 0x5f60 3
3.3.3.3         3.3.3.3          430      0x80000009 0x62d8 3
4.4.4.4         4.4.4.4          425      0x80000009 0x6551 3
5.5.5.5         5.5.5.5          505      0x80000005 0xd45c 4

                Net Link States (Area 0.0.0.0)

Link ID         ADV Router       Age      Seq#       CkSum
10.10.10.1      1.1.1.1           913     0x80000002 0x9277
20.20.20.1      1.1.1.1          1133     0x80000002 0x5b8c
30.30.30.1      1.1.1.1          1053     0x80000002 0x24a1
40.40.40.1      2.2.2.2          2263     0x80000001 0xf2a9
50.50.50.1      3.3.3.3           600     0x80000002 0x8be9
60.60.60.1      4.4.4.4           595     0x80000002 0x2629

                Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID         ADV Router      Age       Seq#       CkSum  Opaque ID
1.0.0.1         1.1.1.1          553      0x80000004 0x2af9 1
1.0.0.1         2.2.2.2          454      0x80000003 0x30ec 1
1.0.0.1         3.3.3.3          460      0x80000004 0x32e1 1
1.0.0.1         4.4.4.4          465      0x80000004 0x36d5 1
1.0.0.1         5.5.5.5          985      0x80000002 0x3ec7 1
1.0.0.8         4.4.4.4          705      0x80000002 0x7938 8
1.0.0.8         5.5.5.5         2257      0x80000001 0x7b32 8
1.0.0.10        1.1.1.1          693      0x80000003 0xd806 10
1.0.0.10        2.2.2.2          694      0x80000003 0x8161 10
1.0.0.12        3.3.3.3          470      0x80000003 0xc725 12
1.0.0.12        5.5.5.5          505      0x80000003 0xa93a 12
1.0.0.22        2.2.2.2          424      0x80000003 0xdb47 22
1.0.0.22        5.5.5.5          445      0x80000003 0x9f76 22
1.0.0.30        1.1.1.1          563      0x80000003 0x7415 30
```

```
1.0.0.30        3.3.3.3         570     0x80000003 0x404e 30
1.0.0.32        1.1.1.1         473     0x80000003 0xc481 32
1.0.0.32        4.4.4.4         525     0x80000003 0xb398 32
PE1#
PE1#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
ospf            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 0
 Total number of IPv4 ECMP paths  : 0

 LFA Non ECMP statistics
 --------------
 Total number of Routes        : 7
 Total number of Primary Paths : 7
 Total number of Backup Paths  : 7
PE1#
PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                   xe12      Passive   OPERATIONAL   30    00:38:05
2.2.2.2                   xe2       Passive   OPERATIONAL   30    00:41:33
3.3.3.3                   xe12      Passive   OPERATIONAL   30    00:39:27
4.4.4.4                   xe13      Passive   OPERATIONAL   30    00:38:42
PE1#
PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
```

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```
K*           0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C            1.1.1.1/32 is directly connected, lo, 00:47:32
O            2.2.2.2/32 [110/11] via 10.10.10.2, xe2, 00:41:44
O            3.3.3.3/32 [110/13] via 10.10.10.2, xe2, 00:38:31
O            4.4.4.4/32 [110/13] via 10.10.10.2, xe2, 00:38:31
O            5.5.5.5/32 [110/12] via 10.10.10.2, xe2, 00:38:33
C            10.10.10.0/24 is directly connected, xe2, 00:45:41
C            10.12.49.0/24 is directly connected, xe0, 16:57:41
C            20.20.20.0/24 is directly connected, xe12, 00:45:41
C            30.30.30.0/24 is directly connected, xe13, 00:45:41
O            40.40.40.0/24 [110/11] via 10.10.10.2, xe2, 00:38:33
O            50.50.50.0/24 [110/12] via 10.10.10.2, xe2, 00:38:31
O            60.60.60.0/24 [110/12] via 10.10.10.2, xe2, 00:38:31
C            127.0.0.0/8 is directly connected, lo, 17:11:17
```

To prohibit an interface from being used as a repair path, disable fast reroute calculation on the interface:

`#configure terminal`	Enter configuration mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip ospf fast-reroute per-prefix candidate disable`	Disable fast reroute calculation on the interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit all the configurations

Verify that the xe2 interface is not used for backup path calculation.

```
PE1#show ip route fast-reroute
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p -
stale info, E - EVPN
       * - candidate default

IP Route Table for VRF "default"
O       2.2.2.2/32 [110/11] via 10.10.10.2, xe1, 00:47:05
                   [FRR-NH] via 30.30.30.2, xe3

O       3.3.3.3/32 [110/13] via 10.10.10.2, xe1, 00:43:52
                   [FRR-NH] via 30.30.30.2, xe3

O       4.4.4.4/32 [110/13] via 10.10.10.2, xe1, 00:43:52
                   [FRR-NH] via 30.30.30.2, xe3

O       5.5.5.5/32 [110/12] via 10.10.10.2, xe1, 00:43:54
                   [FRR-NH] via 30.30.30.2, xe3
```

```
O       40.40.40.0/24 [110/11] via 10.10.10.2, xe1, 00:43:54
                      [FRR-NH] via 30.30.30.2, xe3

O       50.50.50.0/24 [110/12] via 10.10.10.2, xe1, 00:43:52
                      [FRR-NH] via 30.30.30.2, xe3

O       60.60.60.0/24 [110/12] via 10.10.10.2, xe1, 00:43:52
                      [FRR-NH] via 30.30.30.2, xe3

PE1#show ip ospf route fast-reroute

OSPF process 1:
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       OSPF LFA attributes:
       P - Primary, SP - Secondary-Path, LP - Link Protecting,
       NP - Node Protecting, BID - Broadcast Link Protecting
       DP - Downstream Protecting

O  2.2.2.2/32 [11] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
                         via 30.30.30.2, xe3, Area 0.0.0.0
                        Attributes: Metric: [23] ,SP ,BID ,DP
O  3.3.3.3/32 [13] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
                         via 30.30.30.2, xe3, Area 0.0.0.0
                        Attributes: Metric: [23] ,SP ,NP ,BID ,DP
O  4.4.4.4/32 [13] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
                         via 30.30.30.2, xe3, Area 0.0.0.0
                        Attributes: Metric: [21] ,SP ,NP ,BID ,DP
O  5.5.5.5/32 [12] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
                         via 30.30.30.2, xe3, Area 0.0.0.0
                        Attributes: Metric: [22] ,SP ,NP ,BID ,DP
O  20.20.20.0/24 [13] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
                            via 30.30.30.2, xe3, Area 0.0.0.0
                           Attributes: Metric: [23] ,SP ,NP ,BID ,DP
O  30.30.30.0/24 [13] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
                            via 30.30.30.2, xe3, Area 0.0.0.0
                           Attributes: Metric: [21] ,SP ,NP ,BID ,DP
O  40.40.40.0/24 [11] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
                            via 30.30.30.2, xe3, Area 0.0.0.0
                           Attributes: Metric: [22] ,SP ,NP ,BID ,DP
O  50.50.50.0/24 [12] via 10.10.10.2, xe1, Area 0.0.0.0
                        Backup path:
```

```
                        via 30.30.30.2, xe3, Area 0.0.0.0
                       Attributes: Metric: [22] ,SP ,NP ,BID ,DP
O  60.60.60.0/24 [12] via 10.10.10.2, xe1, Area 0.0.0.0
                    Backup path:
                        via 30.30.30.2, xe3, Area 0.0.0.0
                       Attributes: Metric: [21] ,SP ,NP ,BID ,DP

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0         -                -               kernel
1.1.1.1/32          0.0.0.0          lo          -                -            connected
2.2.2.2/32          10.10.10.2       xe1         30.30.30.2       xe3               ospf
3.3.3.3/32          10.10.10.2       xe1         30.30.30.2       xe3               ospf
4.4.4.4/32          10.10.10.2       xe1         30.30.30.2       xe3               ospf
5.5.5.5/32          10.10.10.2       xe1         30.30.30.2       xe3               ospf
10.10.10.0/24       0.0.0.0          xe1         -                -            connected
10.12.49.0/24       0.0.0.0          xe0         -                -            connected
20.20.20.0/24       0.0.0.0          xe2         -                -            connected
30.30.30.0/24       0.0.0.0          xe3         -                -            connected
40.40.40.0/24       10.10.10.2       xe1         30.30.30.2       xe3               ospf
50.50.50.0/24       10.10.10.2       xe1         30.30.30.2       xe3               ospf
60.60.60.0/24       10.10.10.2       xe1         30.30.30.2       xe3               ospf

PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          E >     non-existent        none        No    connected
2.2.2.2/32          NLB>    4.4.4.4             25608       No    30.30.30.2
                    NL      3.3.3.3             25607       No    no nexthop
                    NLP>    2.2.2.2             impl-null   No    10.10.10.2
3.3.3.3/32          NLB>    4.4.4.4             25609       No    30.30.30.2
                    NLP>    2.2.2.2             25601       No    10.10.10.2
                    NL      3.3.3.3             impl-null   No    no nexthop
4.4.4.4/32          NL      3.3.3.3             25608       No    no nexthop
                    NLP>    2.2.2.2             25602       No    10.10.10.2
                    NLB>    4.4.4.4             impl-null   No    30.30.30.2
5.5.5.5/32          NLB>    4.4.4.4             25610       No    30.30.30.2
                    NLP>    2.2.2.2             25600       No    10.10.10.2
                    NL      3.3.3.3             25600       No    no nexthop
10.10.10.0/24       NL      4.4.4.4             25611       No    connected
                    NL      3.3.3.3             25610       No    connected
                    NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
10.12.49.0/24       NL      4.4.4.4             impl-null   No    connected
                    NL      3.3.3.3             impl-null   No    connected
                    NL      2.2.2.2             impl-null   No    connected
```

```
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL      4.4.4.4             25612       No    connected
                    NL      2.2.2.2             25610       No    connected
                    NL      3.3.3.3             impl-null   No    connected
                    E >     non-existent        none        No    connected
30.30.30.0/24       NL      3.3.3.3             25611       No    connected
                    NL      2.2.2.2             25611       No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    E >     non-existent        none        No    connected
40.40.40.0/24       NLB>    4.4.4.4             25613       No    30.30.30.2
                    NL      3.3.3.3             25612       No    no nexthop
                    NLP>    2.2.2.2             impl-null   No    10.10.10.2
50.50.50.0/24       NLB>    4.4.4.4             25614       No    30.30.30.2
                    NLP>    2.2.2.2             25612       No    10.10.10.2
                    NL      3.3.3.3             impl-null   No    no nexthop
60.60.60.0/24       NLP>    2.2.2.2             25609       No    10.10.10.2
                    NL      3.3.3.3             25609       No    no nexthop
                    NLB>    4.4.4.4             impl-null   No    30.30.30.2

PE1#show ldp downstream
Codes: P - Primary route, B - Backup route
Session peer 5.5.5.5:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
Codes: P - Primary route, B - Backup route
Session peer 2.2.2.2:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
  50.50.50.0/24      10.10.10.2      Established     25612      0
P
   30.30.30.0/24       connected        Established      25611       0
   20.20.20.0/24       connected        Established      25610       0
  4.4.4.4/32        10.10.10.2      Established     25602      0
P
  3.3.3.3/32        10.10.10.2      Established     25601      0
P
  60.60.60.0/24      10.10.10.2      Established     25609      0
P
  5.5.5.5/32        10.10.10.2      Established     25600      0
P
  40.40.40.0/24      10.10.10.2      Established     impl-null   0
P
   10.12.49.0/24       connected        Established      impl-null   0
   10.10.10.0/24       connected        Established      impl-null   0
  2.2.2.2/32        10.10.10.2      Established     impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 3.3.3.3:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
   40.40.40.0/24       connected        Established      25612       0
   30.30.30.0/24       connected        Established      25611       0
   10.10.10.0/24       connected        Established      25610       0
```

```
  4.4.4.4/32          connected        Established      25608       0
  2.2.2.2/32          connected        Established      25607       0
  60.60.60.0/24       connected        Established      25609       0
  5.5.5.5/32          connected        Established      25600       0
  50.50.50.0/24       connected        Established      impl-null   0
  20.20.20.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  3.3.3.3/32          connected        Established      impl-null   0
Codes: P - Primary route, B - Backup route
Session peer 4.4.4.4:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
  50.50.50.0/24       connected        Established      25614       0
 50.50.50.0/24      30.30.30.2      Established     25614      0
B
  40.40.40.0/24       connected        Established      25613       0
 40.40.40.0/24      30.30.30.2      Established     25613      0
B
  20.20.20.0/24       connected        Established      25612       0
  10.10.10.0/24       connected        Established      25611       0
  5.5.5.5/32          connected        Established      25610       0
 5.5.5.5/32        30.30.30.2      Established     25610      0
B
  3.3.3.3/32          connected        Established      25609       0
 3.3.3.3/32        30.30.30.2      Established     25609      0
B
  2.2.2.2/32          connected        Established      25608       0
 2.2.2.2/32        30.30.30.2      Established     25608      0
B
  60.60.60.0/24       connected        Established      impl-null   0
 60.60.60.0/24      30.30.30.2      Established     impl-null   0
B
  30.30.30.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  4.4.4.4/32          connected        Established      impl-null   0
 4.4.4.4/32        30.30.30.2      Established     impl-null   0
B

PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
  1.1.1.1/32          connected        Established      none        0           None
  2.2.2.2/32          connected        Established      25608       0
 2.2.2.2/32        30.30.30.2      Established     25608      0
B
  2.2.2.2/32          connected        Established      25607       0
 2.2.2.2/32        10.10.10.2      Established     impl-null   0
P
  3.3.3.3/32          connected        Established      25609       0
 3.3.3.3/32        30.30.30.2      Established     25609      0
B
```

```
 3.3.3.3/32        10.10.10.2     Established     25601      0
P
  3.3.3.3/32          connected        Established      impl-null   0
  4.4.4.4/32          connected        Established      25608       0
 4.4.4.4/32        10.10.10.2     Established     25602      0
P
  4.4.4.4/32          connected        Established      impl-null   0
 4.4.4.4/32        30.30.30.2     Established     impl-null   0
B
  5.5.5.5/32          connected        Established      25610       0
 5.5.5.5/32        30.30.30.2     Established     25610      0
B
 5.5.5.5/32        10.10.10.2     Established     25600      0
P
  5.5.5.5/32          connected        Established      25600       0
  10.10.10.0/24       connected        Established      25611       0
  10.10.10.0/24       connected        Established      25610       0
  10.10.10.0/24       connected        Established      impl-null   0
  10.10.10.0/24       connected        Established      none        0          None
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      none        0          None
  20.20.20.0/24       connected        Established      25612       0
  20.20.20.0/24       connected        Established      25610       0
  20.20.20.0/24       connected        Established      impl-null   0
  20.20.20.0/24       connected        Established      none        0          None
  30.30.30.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      impl-null   0
  30.30.30.0/24       connected        Established      none        0          None
  40.40.40.0/24       connected        Established      25613       0
 40.40.40.0/24     30.30.30.2     Established     25613      0
B
  40.40.40.0/24       connected        Established      25612       0
 40.40.40.0/24     10.10.10.2     Established     impl-null   0
P
  50.50.50.0/24       connected        Established      25614       0
 50.50.50.0/24     30.30.30.2     Established     25614      0
B
 50.50.50.0/24     10.10.10.2     Established     25612      0
P
  50.50.50.0/24       connected        Established      impl-null   0
 60.60.60.0/24     10.10.10.2     Established     25609      0
P
  60.60.60.0/24       connected        Established      25609       0
  60.60.60.0/24       connected        Established      impl-null   0
 60.60.60.0/24     30.30.30.2     Established     impl-null   0
B

UPSTREAM LSP :
  FEC                 State            Label        Req.ID      Attr
  1.1.1.1/32          Established      impl-null    0           None
```

```
  1.1.1.1/32          Established      impl-null   0           None
  1.1.1.1/32          Established      impl-null   0           None
  2.2.2.2/32          Established      25602       0           None
  2.2.2.2/32          Established      25608       0           None
  2.2.2.2/32          Established      25602       0           None
  2.2.2.2/32          Established      25608       0           None
  3.3.3.3/32          Established      25614       0           None
  3.3.3.3/32          Established      25614       0           None
  3.3.3.3/32          Established      25609       0           None
  3.3.3.3/32          Established      25609       0           None
  4.4.4.4/32          Established      25615       0           None
  4.4.4.4/32          Established      25605       0           None
  4.4.4.4/32          Established      25615       0           None
  4.4.4.4/32          Established      25605       0           None
  5.5.5.5/32          Established      25606       0           None
  5.5.5.5/32          Established      25606       0           None
  5.5.5.5/32          Established      25613       0           None
  5.5.5.5/32          Established      25613       0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  40.40.40.0/24       Established      25603       0           None
  40.40.40.0/24       Established      25610       0           None
  40.40.40.0/24       Established      25603       0           None
  40.40.40.0/24       Established      25610       0           None
  50.50.50.0/24       Established      25616       0           None
  50.50.50.0/24       Established      25616       0           None
  50.50.50.0/24       Established      25611       0           None
  50.50.50.0/24       Established      25611       0           None
  60.60.60.0/24       Established      25607       0           None
  60.60.60.0/24       Established      25612       0           None
  60.60.60.0/24       Established      25612       0           None
  60.60.60.0/24       Established      25607       0           None

PE1#show ldp fec prefix 5.5.5.5/32
LSR codes     : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
```

```
5.5.5.5/32          NLB>    4.4.4.4             25610       No    30.30.30.2
                    NLP>    2.2.2.2             25600       No    10.10.10.2
                    NL      3.3.3.3             25600       No    no nexthop

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          1         1         -           Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                     13        -           No    LSP_DEFAULT  25608
xe3       No    30.30.30.2
   L>   3.3.3.3/32          3         9         -           Yes   LSP_DEFAULT  25601
xe1         No    10.10.10.2
                                     14        -           No    LSP_DEFAULT  25609
xe3       No    30.30.30.2
   L>   4.4.4.4/32          5         10        -           Yes   LSP_DEFAULT  25602
xe1         No    10.10.10.2
                                     15        -           No    LSP_DEFAULT  3
xe3       No    30.30.30.2
   L>   5.5.5.5/32          7         7         -           Yes   LSP_DEFAULT  25600
xe1         No    10.10.10.2
                                     16        -           No    LSP_DEFAULT  25610
xe3       No    30.30.30.2
   L>   40.40.40.0/24       2         1         -           Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                     17        -           No    LSP_DEFAULT  25613
xe3       No    30.30.30.2
   L>   50.50.50.0/24       4         11        -           Yes   LSP_DEFAULT  25612
xe1         No    10.10.10.2
                                     18        -           No    LSP_DEFAULT  25614
xe3       No    30.30.30.2
   L>   60.60.60.0/24       6         8         -           Yes   LSP_DEFAULT  25609
xe1         No    10.10.10.2
                                     15        -           No    LSP_DEFAULT  3
xe3       No    30.30.30.2


PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32          7         7         -           Yes   LSP_DEFAULT  25600
xe1         No    10.10.10.2
                                     16        -           No    LSP_DEFAULT  25610
xe3       No    30.30.30.2
```

```
PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 13
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608
    Nexthop addr: 30.30.30.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 2, in intf: - in label: 0  out-segment ix: 14
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25609
    Nexthop addr: 30.30.30.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe1, out label: 25602
    Nexthop addr: 10.10.10.2        cross connect ix: 6, op code: Push

     Backup Cross connect ix: 4, in intf: - in label: 0  out-segment ix: 15
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 15, owner: N/A, Stale: NO, out intf: xe3, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push
```

```
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 6, in intf: - in label: 0  out-segment ix: 16
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 16, owner: LDP, Stale: NO, out intf: xe3, out label: 25610
    Nexthop addr: 30.30.30.2        cross connect ix: 6, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 8, in intf: - in label: 0  out-segment ix: 17
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 17, owner: LDP, Stale: NO, out intf: xe3, out label: 25613
    Nexthop addr: 30.30.30.2        cross connect ix: 8, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push

     Backup Cross connect ix: 10, in intf: - in label: 0  out-segment ix: 18
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 18, owner: LDP, Stale: NO, out intf: xe3, out label: 25614
    Nexthop addr: 30.30.30.2        cross connect ix: 10, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
```

```
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 8, op code: Push

     Backup Cross connect ix: 12, in intf: - in label: 0  out-segment ix: 15
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 15, owner: N/A, Stale: NO, out intf: xe3, out label: 3
    Nexthop addr: 30.30.30.2        cross connect ix: 4, op code: Push



PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 6, in intf: - in label: 0  out-segment ix: 16
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 16, owner: LDP, Stale: NO, out intf: xe3, out label: 25610
    Nexthop addr: 30.30.30.2        cross connect ix: 6, op code: Push


PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID     In-Label   Out-Label   In-Intf    Out-Intf/VRF
Nexthop                  pri    LSP-
Type
   L>   2.2.2.2/32         9          25608       3           N/A        xe1
10.10.10.2               Yes    LSP_
DEFAULT
   L>   4.4.4.4/32         6          25605       25602       N/A        xe1
10.10.10.2               Yes    LSP_
DEFAULT
                                      25605       3           N/A        xe3
30.30.30.2               No     LSP_
```

```
DEFAULT
   L>   2.2.2.2/32        3          25602     3          N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
                                     25602     25608      N/A       xe3
30.30.30.2              No     LSP_
DEFAULT
   L>   40.40.40.0/24     4          25603     3          N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
                                     25603     25613      N/A       xe3
30.30.30.2              No     LSP_
DEFAULT
   L>   5.5.5.5/32        7          25606     25600      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
                                     25606     25610      N/A       xe3
30.30.30.2              No     LSP_
DEFAULT
   L>   60.60.60.0/24     8          25607     25609      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
                                     25607     3          N/A       xe3
30.30.30.2              No     LSP_
DEFAULT
   L>   60.60.60.0/24     13         25612     25609      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
   L>   40.40.40.0/24     11         25610     3          N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
   L>   3.3.3.3/32        10         25609     25601      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
   L>   50.50.50.0/24     12         25611     25612      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
   L>   3.3.3.3/32        15         25614     25601      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
                                     25614     25609      N/A       xe3
30.30.30.2              No     LSP_
DEFAULT
   L>   5.5.5.5/32        14         25613     25600      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
   L>   4.4.4.4/32        16         25615     25602      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
   L>   50.50.50.0/24     17         25616     25612      N/A       xe1
10.10.10.2              Yes    LSP_
DEFAULT
                                     25616     25614      N/A       xe3
30.30.30.2              No     LSP_
```

```
DEFAULT

PE1#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2          1   Full/Backup      00:00:34    10.10.10.2      xe1                  0
3.3.3.3          1   Full/Backup      00:00:31    20.20.20.2      xe2                  0
4.4.4.4          1   Full/Backup      00:00:32    30.30.30.2      xe3                  0

PE1#show ip ospf interface brief
Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
lo           1     0.0.0.0         1          1     Loopback        0            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe1         1     0.0.0.0         4          10    DR              1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe2        1     0.0.0.0         14         15    DR              1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe3        1     0.0.0.0         15         20    DR              1            Up


PE1#show ip ospf database

            OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)

                Router Link States (Area 0.0.0.0)

Link ID         ADV Router       Age     Seq#       CkSum  Link count
1.1.1.1         1.1.1.1          961     0x8000000f 0x5af3 4
2.2.2.2         2.2.2.2          992     0x80000009 0x5f60 3
3.3.3.3         3.3.3.3          918     0x80000009 0x62d8 3
4.4.4.4         4.4.4.4          913     0x80000009 0x6551 3
5.5.5.5         5.5.5.5          994     0x80000005 0xd45c 4

                Net Link States (Area 0.0.0.0)

Link ID         ADV Router       Age     Seq#       CkSum
10.10.10.1      1.1.1.1         1401     0x80000002 0x9277
20.20.20.1      1.1.1.1         1621     0x80000002 0x5b8c
30.30.30.1      1.1.1.1         1541     0x80000002 0x24a1
40.40.40.1      2.2.2.2          422     0x80000002 0xf0aa
50.50.50.1      3.3.3.3         1088     0x80000002 0x8be9
60.60.60.1      4.4.4.4         1083     0x80000002 0x2629

                Area-Local Opaque-LSA (Area 0.0.0.0)
```

```
Link ID         ADV Router      Age      Seq#       CkSum  Opaque ID
1.0.0.1         1.1.1.1         1041     0x80000004 0x2af9 1
1.0.0.1         2.2.2.2          942     0x80000003 0x30ec 1
1.0.0.1         3.3.3.3          948     0x80000004 0x32e1 1
1.0.0.1         4.4.4.4          953     0x80000004 0x36d5 1
1.0.0.1         5.5.5.5         1474     0x80000002 0x3ec7 1
1.0.0.8         4.4.4.4         1193     0x80000002 0x7938 8
1.0.0.8         5.5.5.5          464     0x80000002 0x7933 8
1.0.0.10        1.1.1.1         1181     0x80000003 0xd806 10
1.0.0.10        2.2.2.2         1182     0x80000003 0x8161 10
1.0.0.12        3.3.3.3          958     0x80000003 0xc725 12
1.0.0.12        5.5.5.5          994     0x80000003 0xa93a 12
1.0.0.22        2.2.2.2          912     0x80000003 0xdb47 22
1.0.0.22        5.5.5.5          934     0x80000003 0x9f76 22
1.0.0.30        1.1.1.1         1051     0x80000003 0x7415 30
1.0.0.30        3.3.3.3         1058     0x80000003 0x404e 30
1.0.0.32        1.1.1.1          961     0x80000003 0xc481 32
1.0.0.32        4.4.4.4         1013     0x80000003 0xb398 32

PE1#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
ospf            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 0
 Total number of IPv4 ECMP paths  : 0

 LFA Non ECMP statistics
 --------------
 Total number of Routes        : 7
 Total number of Primary Paths : 7
 Total number of Backup Paths  : 7

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
```

```
xe0                *10.12.49.172    up                    up
xe1                 unassigned      up                    up
xe1                 10.10.10.1      up                    up
xe3                 unassigned      up                    up
xe4                 unassigned      up                    up
xe5                 unassigned      up                    up
xe6                 unassigned      up                    up
xe7                 unassigned      up                    up
xe8                 unassigned      up                    up
xe9                 unassigned      up                    up
xe10                unassigned      up                    up
xe11                unassigned      up                    up
xe2                20.20.20.1      up                    up
xe3                30.30.30.1      up                    up
lo                   127.0.0.1       up                    up

PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                   xe2      Passive   OPERATIONAL   30    00:45:56
2.2.2.2                   xe1       Passive   OPERATIONAL   30    00:49:24
3.3.3.3                   xe2      Passive   OPERATIONAL   30    00:47:18
4.4.4.4                   xe3      Passive   OPERATIONAL   30    00:46:33

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C             1.1.1.1/32 is directly connected, lo, 00:55:17
O             2.2.2.2/32 [110/11] via 10.10.10.2, xe1, 00:49:29
O             3.3.3.3/32 [110/13] via 10.10.10.2, xe1, 00:46:16
O             4.4.4.4/32 [110/13] via 10.10.10.2, xe1, 00:46:16
O             5.5.5.5/32 [110/12] via 10.10.10.2, xe1, 00:46:18
C             10.10.10.0/24 is directly connected, xe1, 00:53:26
C             10.12.49.0/24 is directly connected, xe0, 17:05:26
C             20.20.20.0/24 is directly connected, xe2, 00:53:26
C             30.30.30.0/24 is directly connected, xe3, 00:53:26
O             40.40.40.0/24 [110/11] via 10.10.10.2, xe1, 00:46:18
O             50.50.50.0/24 [110/12] via 10.10.10.2, xe1, 00:46:16
O             60.60.60.0/24 [110/12] via 10.10.10.2, xe1, 00:46:16
C             127.0.0.0/8 is directly connected, lo, 17:19:02
```

```
PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0         -                -                kernel
1.1.1.1/32          0.0.0.0          lo          -                -                connected
2.2.2.2/32          10.10.10.2       xe1         30.30.30.2       xe3              ospf
3.3.3.3/32          10.10.10.2       xe1         30.30.30.2       xe3              ospf
4.4.4.4/32          10.10.10.2       xe1         30.30.30.2       xe3              ospf
5.5.5.5/32          10.10.10.2       xe1         30.30.30.2       xe3              ospf
10.10.10.0/24       0.0.0.0          xe1         -                -                connected
10.12.49.0/24       0.0.0.0          xe0         -                -                connected
20.20.20.0/24       0.0.0.0          xe2         -                -                connected
30.30.30.0/24       0.0.0.0          xe3         -                -                connected
40.40.40.0/24       10.10.10.2       xe1         30.30.30.2       xe3              ospf
50.50.50.0/24       10.10.10.2       xe1         30.30.30.2       xe3              ospf
60.60.60.0/24       10.10.10.2       xe1         30.30.30.2       xe3              ospf

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -           Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                    13        -           No    LSP_DEFAULT  25608
xe3        No    30.30.30.2
   L>   3.3.3.3/32         3         9         -           Yes   LSP_DEFAULT  25601
xe1         No    10.10.10.2
                                    14        -           No    LSP_DEFAULT  25609
xe3        No    30.30.30.2
   L>   4.4.4.4/32         5         10        -           Yes   LSP_DEFAULT  25602
xe1         No    10.10.10.2
                                    15        -           No    LSP_DEFAULT  3
xe3        No    30.30.30.2
   L>   5.5.5.5/32         7         7         -           Yes   LSP_DEFAULT  25600
xe1         No    10.10.10.2
                                    16        -           No    LSP_DEFAULT  25610
xe3        No    30.30.30.2
   L>   40.40.40.0/24      2         1         -           Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                    17        -           No    LSP_DEFAULT  25613
xe3        No    30.30.30.2
   L>   50.50.50.0/24      4         11        -           Yes   LSP_DEFAULT  25612
xe1         No    10.10.10.2
                                    18        -           No    LSP_DEFAULT  25614
xe3        No    30.30.30.2
   L>   60.60.60.0/24      6         8         -           Yes   LSP_DEFAULT  25609
xe1         No    10.10.10.2
                                    15        -           No    LSP_DEFAULT  3
xe3        No    30.30.30.2

PE1#show mpls forwarding-table 5.5.5.5/32
```

```
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC              FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        7         -          Yes   LSP_DEFAULT  25600
xe1        No    10.10.10.2
                                    16        -          No    LSP_DEFAULT  25610
xe3       No    30.30.30.2
```

```
PE1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
       K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label     Out-Label   In-Intf    Out-Intf/VRF       Nexthop                 pri    LSP-
Type
   L>   2.2.2.2/32         9           25608       3           N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
   L>   4.4.4.4/32         6           25605       25602       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
                                       25605       3           N/A        xe3           30.30.30.2              No     LSP_
DEFAULT
   L>   2.2.2.2/32         3           25602       3           N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
                                       25602       25608       N/A        xe3           30.30.30.2              No     LSP_
DEFAULT
   L>   40.40.40.0/24      4           25603       3           N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
                                       25603       25613       N/A        xe3           30.30.30.2              No     LSP_
DEFAULT
   L>   5.5.5.5/32         7           25606       25600       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
                                       25606       25610       N/A        xe3           30.30.30.2              No     LSP_
DEFAULT
   L>   60.60.60.0/24      8           25607       25609       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
                                       25607       3           N/A        xe3           30.30.30.2              No     LSP_
DEFAULT
   L>   60.60.60.0/24      13          25612       25609       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
   L>   40.40.40.0/24      11          25610       3           N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
   L>   3.3.3.3/32         10          25609       25601       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
   L>   50.50.50.0/24      12          25611       25612       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
   L>   3.3.3.3/32         15          25614       25601       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
                                       25614       25609       N/A        xe3           30.30.30.2              No     LSP_
DEFAULT
   L>   5.5.5.5/32         14          25613       25600       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
   L>   4.4.4.4/32         16          25615       25602       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
   L>   50.50.50.0/24      17          25616       25612       N/A        xe1            10.10.10.2              Yes    LSP_
DEFAULT
                                       25616       25614       N/A        xe3           30.30.30.2              No     LSP_
DEFAULT
```

LDP-FRR with ISIS as IGP Configuration

Below are the configurations and validations involving NSM, ISIS, LDP before configuring fast-reroute for IGP and LDP.

PE1

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 1.1.1.1`	Set the router ID to IP address 1.1.1.1
`(config-router)#transport-address ipv4 1.1.1.1 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#targeted-peer ipv4 5.5.5.5`	Configure targeted peer.
`(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.10.1/24`	Configure IPv4 address for xe1.
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#isis wide-metric 20 level-1`	Assign isis wide-metric to the interface
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 20.20.20.1/24`	Configure IPv4 address for xe2
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#isis wide-metric 15 level-1`	Assign isis wide-metric to the interface

`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe3`	Enter interface mode.
`(config-if)#ip address 30.30.30.1/24`	Configure IPv4 address for xe3
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe3
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe3
`(config-if)#isis wide-metric 60 level-1`	Assign isis wide-metric to the interface
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe3 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#router isis 1`	Create an IS-IS routing instance for area 49 with instance 1
`(config-router)#net 49.0001.0000.0000.0001.00`	Establish a Network Entity Title for this instance, specifying the area address and the system ID
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance
`(config-router)#is-type level-1`	Configure instance as level-1-only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1.
`(config-router)#bfd all-interfaces`	Enable BFD for ISIS on all interfaces
`(config-router)#capability cspf`	Enable CSPF feature for ISIS instance.
`(config-if)#exit`	Exit interface mode.
`(config)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval
`(config)#commit`	Commit all the configurations

P1

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to 2.2.2.2/32
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.

`(config-router)#router-id 2.2.2.2`	Set the router ID to IP address 2.2.2.2
`(config-router)#transport-address ipv4 2.2.2.2 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.10.2/24`	Configure IPv4 address for xe1.
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 40.40.40.1/24`	Configure IPv4 address for xe2
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#router isis 1`	Create an IS-IS routing instance for area 49 with instance 1
`(config-router)#net 49.0001.0000.0000.0002.00`	Establish a Network Entity Title for this instance, specifying the area address and the system ID
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance
`(config-router)#is-type level-1`	Configure instance as level-1-only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1.
`(config-router)#bfd all-interfaces`	Enable BFD for ISIS on all interfaces
`(config-router)#capability cspf`	Enable CSPF feature for ISIS instance.
`(config-if)#exit`	Exit interface mode.

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`(config)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval
`(config)#commit`	Commit all the configurations

P2

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 3.3.3.3/32 secondary`	Set the IP address of the loopback interface to 3.3.3.3/32
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 3.3.3.3`	Set the router ID to IP address 3.3.3.3
`(config-router)#transport-address ipv4 3.3.3.3 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 20.20.20.2/24`	Configure IPv4 address for xe1.
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 50.50.50.1/24`	Configure IPv4 address for xe2
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.

`(config-if)#exit`	Exit interface mode
`(config)#router isis 1`	Create an IS-IS routing instance for area 49 with instance 1
`(config-router)#net 49.0001.0000.0000.0003.00`	Establish a Network Entity Title for this instance, specifying the area address and the system ID
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance
`(config-router)#is-type level-1`	Configure instance as level-1-only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1.
`(config-router)#bfd all-interfaces`	Enable BFD for ISIS on all interfaces
`(config-router)#capability cspf`	Enable CSPF feature for ISIS instance.
`(config-if)#exit`	Exit interface mode.
`(config)#bfd interval 3 minrx 3 multiplier 3`	Configure BFD interval
`(config)#commit`	Commit all the configurations

P3

`#configure terminal`	Enter configuration mode.
`(config)#interface lo`	Specify the loopback (lo) interface to be configured.
`(config-if)#ip address 4.4.4.4/32 secondary`	Set the IP address of the loopback interface to 4.4.4.4/32
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#exit`	Exit interface mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#router-id 4.4.4.4`	Set the router ID to IP address 4.4.4.4
`(config-router)#transport-address ipv4 4.4.4.4 0`	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
`(config-router)#exit`	Exit router mode
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 30.30.30.2/24`	Configure IPv4 address for xe1.
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.

(config-if)#ip address 60.60.60.1/24	Configure IPv4 address for xe2
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#enable-ldp ipv4	Enable LDP for IPv4 on xe2.
(config-if)#mpls ldp-igp sync isis level-1	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
(config-if)#exit	Exit interface mode
(config)#router isis 1	Create an IS-IS routing instance for area 49 with instance 1
(config-router)#net 49.0001.0000.0000.0004.00	Establish a Network Entity Title for this instance, specifying the area address and the system ID
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)#bfd all-interfaces	Enable BFD for ISIS on all interfaces
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

PE2

#configure terminal	Enter configuration mode.
(config)#interface lo	Specify the loopback (lo) interface to be configured.
(config-if)#ip address 5.5.5.5/32 secondary	Set the IP address of the loopback interface to 5.5.5.5/32
(config-if)#ip router isis 1	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
(config-if)#exit	Exit interface mode.
(config)#router ldp	Enter router mode for LDP.
(config-router)#router-id 5.5.5.5	Set the router ID to IP address 5.5.5.5
(config-router)#transport-address ipv4 5.5.5.5 0	Configure the transport address for IPv4 (for IPv6 use ipv6) to be used for a TCP session over which LDP will run. Note: It is preferable to use the loopback address as the transport address.
(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
(config-router-targeted-peer)#exit	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe1	Enter interface mode.

`(config-if)#ip address 40.40.40.2/24`	Configure IPv4 address for xe1.
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe1.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe1.
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe1 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 50.50.50.2/24`	Configure IPv4 address for xe2
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe2.
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe2.
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe2 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#interface xe3`	Enter interface mode.
`(config-if)#ip address 60.60.60.2/24`	Configure IPv4 address for xe3
`(config-if)#ip router isis 1`	Configure IS-IS IPv4 routing on the interface with IS-IS tag instance 1.
`(config-if)#label-switching`	Enable label switching on interface xe3
`(config-if)#enable-ldp ipv4`	Enable LDP for IPv4 on xe3
`(config-if)#mpls ldp-igp sync isis level-1`	Configure LDP-IGP Synchronization for interface xe3 belonging to an IS-IS process with corresponding IS-IS level. The values level-1|level-2-only|level-1-2 identify the IS-IS level instance. The interface can be acting on any level, but the sync is applicable only when it matches with the level given in IGP sync command. IS-IS: This command is part of ISIS Process. Default: Mandatory configuration. No default option.
`(config-if)#exit`	Exit interface mode
`(config)#router isis 1`	Create an IS-IS routing instance for area 49 with instance 1
`(config-router)#net 49.0001.0000.0000.0005.00`	Establish a Network Entity Title for this instance, specifying the area address and the system ID
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance

(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)#bfd all-interfaces	Enable BFD for ISIS on all interfaces
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-if)#exit	Exit interface mode.
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#commit	Commit all the configurations

Validation

```
PE1#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P1             xe1         5254.0002.5b0a      Up     28        L1   IS-IS
P2             xe2        5254.009b.f9a2      Up     6         L1   IS-IS
P3             xe3        5254.005d.e995      Up     8         L1   IS-IS

PE1#show clns neighbors detail

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P1             xe1         5254.0002.5b0a      Up     25        L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:14:43
  Area Address(es): 49.0001
  IP Address(es): 10.10.10.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P2             xe2        5254.009b.f9a2      Up     7         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:14:19
  Area Address(es): 49.0001
  IP Address(es): 20.20.20.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
```

```
P3             xe3       5254.005d.e995      Up     5         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:13:54
  Area Address(es): 49.0001
  IP Address(es): 30.30.30.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise

PE1#show isis database
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                  LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00            * 0x0000000A   0xDB9F        379               0/0/0
PE1.02-00            * 0x00000001   0x8843        319               0/0/0
P1.00-00               0x00000008   0xC257        446               0/0/0
P1.03-00               0x00000001   0xBE07        406               0/0/0
P2.00-00               0x00000007   0x0352        450               0/0/0
P2.02-00               0x00000001   0x7652        342               0/0/0
P2.03-00               0x00000001   0xBF04        436               0/0/0
P3.00-00               0x00000007   0xE1AE        471               0/0/0
P3.02-00               0x00000001   0x774F        357               0/0/0
PE2.00-00              0x0000000A   0xE3FE        467               0/0/0
PE2.04-00              0x00000001   0xA619        466               0/0/0

PE1#show isis database verbose
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                  LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00            * 0x0000000A   0xDB9F        369               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE1
  IP Address:   1.1.1.1
  Router ID:    10.12.49.172
  Metric:   20         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.1
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```
    TE-Default Metric: 20
  Metric:   15         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.1
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 15
  Metric:   60         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.1
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 60
  Metric:   10         IP-Extended 1.1.1.1/32
  Metric:   20         IP-Extended 10.10.10.0/24
  Metric:   15         IP-Extended 20.20.20.0/24
  Metric:   60         IP-Extended 30.30.30.0/24
PE1.02-00          * 0x00000001   0x8843        309                0/0/0
  Metric:   0          IS-Extended PE1.00
  Metric:   0          IS-Extended P1.00
P1.00-00             0x00000008   0xC257        436                0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P1
  IP Address:   2.2.2.2
  Router ID:    10.12.49.173
  Metric:   10         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.2
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
```

```
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.1
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 2.2.2.2/32
  Metric:   10         IP-Extended 10.10.10.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
P1.03-00              0x00000001   0xBE07        396              0/0/0
  Metric:   0          IS-Extended P1.00
  Metric:   0          IS-Extended PE2.00
P2.00-00              0x00000007   0x0352        440              0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P2
  IP Address:   3.3.3.3
  Router ID:    10.12.49.176
  Metric:   10         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.2
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.1
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 3.3.3.3/32
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 20.20.20.0/24
P2.02-00              0x00000001   0x7652        332                 0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE1.00
P2.03-00              0x00000001   0xBF04        426                 0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE2.00
P3.00-00              0x00000007   0xE1AE        461                 0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P3
  IP Address:   4.4.4.4
  Router ID:    10.12.49.177
  Metric:   10         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.2
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.1
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
```

```
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 4.4.4.4/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 30.30.30.0/24
P3.02-00              0x00000001   0x774F        347               0/0/0
  Metric:   0          IS-Extended P3.00
  Metric:   0          IS-Extended PE1.00
PE2.00-00             0x0000000A   0xE3FE        457               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE2
  IP Address:   5.5.5.5
  Router ID:    10.12.49.174
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.2
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.2
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
```

```
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.2
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 5.5.5.5/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
PE2.04-00            0x00000001   0xA619        456               0/0/0
  Metric:   0          IS-Extended PE2.00
  Metric:   0          IS-Extended P3.00


PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                   xe3      Passive   OPERATIONAL   30    00:12:46
2.2.2.2                   xe1       Passive   OPERATIONAL   30    00:14:48
3.3.3.3                   xe2      Passive   OPERATIONAL   30    00:14:00
4.4.4.4                   xe3      Passive   OPERATIONAL   30    00:14:07

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C             1.1.1.1/32 is directly connected, lo, 00:23:10
i L1          2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:15:11
```

```
i L1        3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:13:41
i L1        4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:12:01
i L1        5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:12:51
C           10.10.10.0/24 is directly connected, xe1, 00:23:10
C           10.12.49.0/24 is directly connected, xe0, 00:27:49
C           20.20.20.0/24 is directly connected, xe2, 00:23:10
C           30.30.30.0/24 is directly connected, xe3, 00:23:10
i L1        40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:12:51
i L1        50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:12:51
i L1        60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:12:51
C           127.0.0.0/8 is directly connected, lo, 02:59:00

PE1#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
isis            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 0
 Total number of IPv4 ECMP paths  : 0

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
xe0                 *10.12.49.172    up                    up
xe1                  unassigned      up                    up
xe1                  10.10.10.1      up                    up
xe3                  unassigned      up                    up
xe4                  unassigned      up                    up
xe5                  unassigned      up                    up
xe6                  unassigned      up                    up
xe7                  unassigned      up                    up
xe8                  unassigned      up                    up
xe9                  unassigned      up                    up
xe10                 unassigned      up                    up
xe11                 unassigned      up                    up
xe2                 20.20.20.1      up                    up
```

```
xe3                 30.30.30.1      up                     up
lo                    127.0.0.1       up                     up

PE1#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf         Owner
0.0.0.0/0           10.12.49.1       xe0         kernel
1.1.1.1/32          0.0.0.0          lo           connected
2.2.2.2/32          10.10.10.2       xe1         isis
3.3.3.3/32          20.20.20.2       xe2        isis
4.4.4.4/32          20.20.20.2       xe2        isis
5.5.5.5/32          20.20.20.2       xe2        isis
10.10.10.0/24       0.0.0.0          xe1         connected
10.12.49.0/24       0.0.0.0          xe0         connected
20.20.20.0/24       0.0.0.0          xe2        connected
30.30.30.0/24       0.0.0.0          xe3        connected
40.40.40.0/24       10.10.10.2       xe1         isis
50.50.50.0/24       20.20.20.2       xe2        isis
60.60.60.0/24       20.20.20.2       xe2        isis

PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          E >     non-existent        none        No    connected
2.2.2.2/32          NL      4.4.4.4             25608       No    no nexthop
                    NL      3.3.3.3             25608       No    no nexthop
                    NL>     2.2.2.2             impl-null   No    10.10.10.2
3.3.3.3/32          NL      2.2.2.2             25608       No    no nexthop
                    NL      4.4.4.4             25609       No    no nexthop
                    NL>     3.3.3.3             impl-null   No    20.20.20.2
4.4.4.4/32          NL      2.2.2.2             25609       No    no nexthop
                    NL>     3.3.3.3             25609       No    20.20.20.2
                    NL      4.4.4.4             impl-null   No    no nexthop
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NL>     3.3.3.3             25610       No    20.20.20.2
                    NL      2.2.2.2             25600       No    no nexthop
10.10.10.0/24       NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
10.12.49.0/24       NL      3.3.3.3             impl-null   No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    NL      2.2.2.2             impl-null   No    connected
```

```
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL      3.3.3.3             impl-null   No    connected
                    E >     non-existent        none        No    connected
30.30.30.0/24       NL      2.2.2.2             25610       No    connected
                    NL      3.3.3.3             25611       No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    E >     non-existent        none        No    connected
40.40.40.0/24       NL      4.4.4.4             25611       No    no nexthop
                    NL      3.3.3.3             25612       No    no nexthop
                    NL>     2.2.2.2             impl-null   No    10.10.10.2
50.50.50.0/24       NL      2.2.2.2             25611       No    no nexthop
                    NL      4.4.4.4             25612       No    no nexthop
                    NL>     3.3.3.3             impl-null   No    20.20.20.2
60.60.60.0/24       NL      2.2.2.2             25612       No    no nexthop
                    NL>     3.3.3.3             25613       No    20.20.20.2
                    NL      4.4.4.4             impl-null   No    no nexthop

PE1#show ldp downstream
Session peer 5.5.5.5:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
Session peer 2.2.2.2:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
  60.60.60.0/24       connected        Established      25612        0
  50.50.50.0/24       connected        Established      25611        0
  30.30.30.0/24       connected        Established      25610        0
  4.4.4.4/32          connected        Established      25609        0
  3.3.3.3/32          connected        Established      25608        0
  5.5.5.5/32          connected        Established      25600        0
  40.40.40.0/24       10.10.10.2       Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  10.10.10.0/24       connected        Established      impl-null    0
  2.2.2.2/32          10.10.10.2       Established      impl-null    0
Session peer 3.3.3.3:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
  40.40.40.0/24       connected        Established      25612        0
  30.30.30.0/24       connected        Established      25611        0
  4.4.4.4/32          20.20.20.2       Established      25609        0
  2.2.2.2/32          connected        Established      25608        0
  60.60.60.0/24       20.20.20.2       Established      25613        0
  5.5.5.5/32          20.20.20.2       Established      25610        0
  50.50.50.0/24       20.20.20.2       Established      impl-null    0
  20.20.20.0/24       connected        Established      impl-null    0
  10.12.49.0/24       connected        Established      impl-null    0
  3.3.3.3/32          20.20.20.2       Established      impl-null    0
Session peer 4.4.4.4:
  FEC                 Nexthop Addr     State            Label        Req.ID      Attr
  50.50.50.0/24       connected        Established      25612        0
  40.40.40.0/24       connected        Established      25611        0
  5.5.5.5/32          connected        Established      25610        0
  3.3.3.3/32          connected        Established      25609        0
```

```
  2.2.2.2/32          connected         Established       25608       0
  60.60.60.0/24       connected         Established       impl-null   0
  30.30.30.0/24       connected         Established       impl-null   0
  10.12.49.0/24       connected         Established       impl-null   0
  4.4.4.4/32          connected         Established       impl-null   0


PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC                 Nexthop Addr      State             Label       Req.ID      Attr
  1.1.1.1/32          connected         Established       none        0           None
  2.2.2.2/32          connected         Established       25608       0
  2.2.2.2/32          connected         Established       25608       0
  2.2.2.2/32          10.10.10.2        Established       impl-null   0
  3.3.3.3/32          connected         Established       25608       0
  3.3.3.3/32          connected         Established       25609       0
  3.3.3.3/32          20.20.20.2        Established       impl-null   0
  4.4.4.4/32          connected         Established       25609       0
  4.4.4.4/32          20.20.20.2        Established       25609       0
  4.4.4.4/32          connected         Established       impl-null   0
  5.5.5.5/32          connected         Established       25610       0
  5.5.5.5/32          20.20.20.2        Established       25610       0
  5.5.5.5/32          connected         Established       25600       0
  10.10.10.0/24       connected         Established       impl-null   0
  10.10.10.0/24       connected         Established       none        0           None
  10.12.49.0/24       connected         Established       impl-null   0
  10.12.49.0/24       connected         Established       impl-null   0
  10.12.49.0/24       connected         Established       impl-null   0
  10.12.49.0/24       connected         Established       none        0           None
  20.20.20.0/24       connected         Established       impl-null   0
  20.20.20.0/24       connected         Established       none        0           None
  30.30.30.0/24       connected         Established       25610       0
  30.30.30.0/24       connected         Established       25611       0
  30.30.30.0/24       connected         Established       impl-null   0
  30.30.30.0/24       connected         Established       none        0           None
  40.40.40.0/24       connected         Established       25611       0
  40.40.40.0/24       connected         Established       25612       0
  40.40.40.0/24       10.10.10.2        Established       impl-null   0
  50.50.50.0/24       connected         Established       25611       0
  50.50.50.0/24       connected         Established       25612       0
  50.50.50.0/24       20.20.20.2        Established       impl-null   0
  60.60.60.0/24       connected         Established       25612       0
  60.60.60.0/24       20.20.20.2        Established       25613       0
  60.60.60.0/24       connected         Established       impl-null   0

UPSTREAM LSP :
  FEC                 State             Label        Req.ID       Attr
  1.1.1.1/32          Established       impl-null    0            None
  1.1.1.1/32          Established       impl-null    0            None
  1.1.1.1/32          Established       impl-null    0            None
```

```
  2.2.2.2/32          Established      25604       0           None
  2.2.2.2/32          Established      25608       0           None
  3.3.3.3/32          Established      25605       0           None
  3.3.3.3/32          Established      25600       0           None
  4.4.4.4/32          Established      25603       0           None
  4.4.4.4/32          Established      25602       0           None
  4.4.4.4/32          Established      25603       0           None
  4.4.4.4/32          Established      25602       0           None
  5.5.5.5/32          Established      25614       0           None
  5.5.5.5/32          Established      25615       0           None
  5.5.5.5/32          Established      25615       0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.10.10.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  40.40.40.0/24       Established      25606       0           None
  40.40.40.0/24       Established      25610       0           None
  50.50.50.0/24       Established      25607       0           None
  50.50.50.0/24       Established      25601       0           None
  60.60.60.0/24       Established      25616       0           None
  60.60.60.0/24       Established      25617       0           None
  60.60.60.0/24       Established      25617       0           None

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -          Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
   L>   3.3.3.3/32         5         3         -          Yes   LSP_DEFAULT  3
xe2        No    20.20.20.2
   L>   4.4.4.4/32         3         7         -          Yes   LSP_DEFAULT  25609
xe2        No    20.20.20.2
   L>   5.5.5.5/32         7         5         -          Yes   LSP_DEFAULT  25610
xe2        No    20.20.20.2
   L>   40.40.40.0/24      2         1         -          Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
   L>   50.50.50.0/24      6         3         -          Yes   LSP_DEFAULT  3
xe2        No    20.20.20.2
```

```
   L>   60.60.60.0/24      4        6        -          Yes   LSP_DEFAULT  25613
xe2       No    20.20.20.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        5        -          Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
```

```
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613
    Nexthop addr: 20.20.20.2        cross connect ix: 6, op code: Push


PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
```

```
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NL>     3.3.3.3             25610       No    20.20.20.2
                    NL      2.2.2.2             25600       No    no nexthop

PE2:

PE2#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P3             xe3       5254.0015.057e      Up     25        L1   IS-IS
P2             xe2        5254.007b.6b14      Up     6          L1   IS-IS
P1             xe1        5254.00ea.0b3a      Up     6          L1   IS-IS

PE2#show clns neighbors detail

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P3             xe3       5254.0015.057e      Up     21        L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:18:38
  Area Address(es): 49.0001
  IP Address(es): 60.60.60.1
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P2             xe2        5254.007b.6b14      Up     5          L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:19:18
  Area Address(es): 49.0001
  IP Address(es): 50.50.50.1
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
```

```
P1              xe1        5254.00ea.0b3a      Up     5         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:19:48
  Area Address(es): 49.0001
  IP Address(es): 40.40.40.1
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise

PE2#show isis database
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00             0x0000000B   0xD9A0        881               0/0/0
PE1.02-00             0x00000002   0x8644        821               0/0/0
P1.00-00              0x00000009   0xC058        949               0/0/0
P1.03-00              0x00000002   0xBC08        909               0/0/0
P2.00-00              0x00000008   0x0153        953               0/0/0
P2.02-00              0x00000002   0x7453        845               0/0/0
P2.03-00              0x00000002   0xBD05        939               0/0/0
P3.00-00              0x00000008   0xDFAF        974               0/0/0
P3.02-00              0x00000002   0x7550        860               0/0/0
PE2.00-00           * 0x0000000B   0xE1FF        971               0/0/0
PE2.04-00           * 0x00000002   0xA41A        970               0/0/0

PE2#show isis database verbose
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00             0x0000000B   0xD9A0        871               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE1
  IP Address:   1.1.1.1
  Router ID:    10.12.49.172
  Metric:   20         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.1
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```
    TE-Default Metric: 20
  Metric:   15         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.1
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 15
  Metric:   60         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.1
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 60
  Metric:   10         IP-Extended 1.1.1.1/32
  Metric:   20         IP-Extended 10.10.10.0/24
  Metric:   15         IP-Extended 20.20.20.0/24
  Metric:   60         IP-Extended 30.30.30.0/24
PE1.02-00            0x00000002   0x8644        811                0/0/0
  Metric:   0          IS-Extended PE1.00
  Metric:   0          IS-Extended P1.00
P1.00-00             0x00000009   0xC058        940                0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P1
  IP Address:   2.2.2.2
  Router ID:    10.12.49.173
  Metric:   10         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.2
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
```

```
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.1
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 2.2.2.2/32
  Metric:   10         IP-Extended 10.10.10.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
P1.03-00              0x00000002   0xBC08       899               0/0/0
  Metric:   0          IS-Extended P1.00
  Metric:   0          IS-Extended PE2.00
P2.00-00              0x00000008   0x0153       943               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P2
  IP Address:   3.3.3.3
  Router ID:    10.12.49.176
  Metric:   10         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.2
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.1
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 3.3.3.3/32
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 20.20.20.0/24
P2.02-00              0x00000002   0x7453        835               0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE1.00
P2.03-00              0x00000002   0xBD05        929               0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE2.00
P3.00-00              0x00000008   0xDFAF        964               0/0/0
  Area Address: 49.0001
  NLPID:         0xCC
  Hostname:      P3
  IP Address:    4.4.4.4
  Router ID:     10.12.49.177
  Metric:   10         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.2
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.1
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
```

```
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 4.4.4.4/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 30.30.30.0/24
P3.02-00              0x00000002   0x7550        850               0/0/0
  Metric:   0          IS-Extended P3.00
  Metric:   0          IS-Extended PE1.00
PE2.00-00           * 0x0000000B   0xE1FF        961               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE2
  IP Address:   5.5.5.5
  Router ID:    10.12.49.174
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.2
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.2
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
```

```
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.2
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 5.5.5.5/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
PE2.04-00          * 0x00000002   0xA41A        960              0/0/0
  Metric:   0          IS-Extended PE2.00
  Metric:   0          IS-Extended P3.00

PE2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
1.1.1.1                   xe2       Active    OPERATIONAL   30    00:19:22
2.2.2.2                   xe1       Active    OPERATIONAL   30    00:19:27
3.3.3.3                   xe2       Active    OPERATIONAL   30    00:19:24
4.4.4.4                   xe3      Active    OPERATIONAL   30    00:19:12


PE2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
i L1          1.1.1.1/32 [115/30] via 60.60.60.1, xe1, 00:20:03
                         [115/30] via 50.50.50.1, xe2
```

```
                        [115/30] via 40.40.40.1, xe1
i L1         2.2.2.2/32 [115/20] via 40.40.40.1, xe1, 00:19:01
i L1         3.3.3.3/32 [115/20] via 50.50.50.1, xe2, 00:19:01
i L1         4.4.4.4/32 [115/20] via 60.60.60.1, xe1, 00:19:01
C            5.5.5.5/32 is directly connected, lo, 00:26:47
i L1         10.10.10.0/24 [115/20] via 40.40.40.1, xe1, 00:19:01
C            10.12.49.0/24 is directly connected, xe0, 00:38:00
i L1         20.20.20.0/24 [115/20] via 50.50.50.1, xe2, 00:19:01
i L1         30.30.30.0/24 [115/20] via 60.60.60.1, xe1, 00:19:01
C            40.40.40.0/24 is directly connected, xe1, 00:26:47
C            50.50.50.0/24 is directly connected, xe2, 00:26:47
C            60.60.60.0/24 is directly connected, xe1, 00:26:47
C            127.0.0.0/8 is directly connected, lo, 03:05:08


PE2#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 16
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
isis            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 1
 Total number of IPv4 ECMP paths  : 3
 Number of routes with  3 ECMP paths: 1

PE2#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
xe0                 *10.12.49.174    up                    up
xe3                 60.60.60.2      up                    up
xe2                  unassigned      up                    up
xe2                  50.50.50.2      up                    up
xe4                  unassigned      up                    up
xe5                  unassigned      up                    up
xe6                  unassigned      up                    up
xe7                  unassigned      up                    up
xe1                  40.40.40.2      up                    up
```

```
xe9                 unassigned      up                    up
xe10                unassigned      up                    up
xe11                unassigned      up                    up
xe12                unassigned      up                    up
xe13                unassigned      up                    up
lo                   127.0.0.1       up                    up

PE2#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path



PE2#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Owner
0.0.0.0/0           10.12.49.1       xe0        kernel
1.1.1.1/32          40.40.40.1       xe1        isis
                    60.60.60.1       xe3       isis
                    50.50.50.1       xe2        isis
2.2.2.2/32          40.40.40.1       xe1        isis
3.3.3.3/32          50.50.50.1       xe2        isis
4.4.4.4/32          60.60.60.1       xe3       isis
5.5.5.5/32          0.0.0.0          lo          connected
10.10.10.0/24       40.40.40.1       xe1        isis
10.12.49.0/24       0.0.0.0          xe0        connected
20.20.20.0/24       50.50.50.1       xe2        isis
30.30.30.0/24       60.60.60.1       xe3       isis
40.40.40.0/24       0.0.0.0          xe1        connected
50.50.50.0/24       0.0.0.0          xe2        connected
60.60.60.0/24       0.0.0.0          xe3       connected

PE2#show ldp fec
LSR codes     : E/N - LSR is egress/non-egress for this FEC,
                L - LSR received a label for this FEC,
                > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          NL>     4.4.4.4             25600       No    60.60.60.1
                    NL>     3.3.3.3             25600       No    50.50.50.1
                    NL>     2.2.2.2             25601       No    40.40.40.1
2.2.2.2/32          NL>     2.2.2.2             impl-null   No    40.40.40.1
3.3.3.3/32          NL>     3.3.3.3             impl-null   No    50.50.50.1
4.4.4.4/32          NL>     4.4.4.4             impl-null   No    60.60.60.1
5.5.5.5/32          E >     non-existent        none        No    connected
10.10.10.0/24       NL>     2.2.2.2             impl-null   No    40.40.40.1
10.12.49.0/24       NL      4.4.4.4             impl-null   No    connected
                    NL      3.3.3.3             impl-null   No    connected
                    NL      2.2.2.2             impl-null   No    connected
```

```
                    E >     non-existent        none        No     connected
20.20.20.0/24       NL      4.4.4.4             25605       No     no nexthop
                    NL>     3.3.3.3             impl-null   No     50.50.50.1
                    NL      2.2.2.2             25604       No     no nexthop
30.30.30.0/24       NL>     4.4.4.4             impl-null   No     60.60.60.1
40.40.40.0/24       NL      2.2.2.2             impl-null   No     connected
                    E >     non-existent        none        No     connected
50.50.50.0/24       NL      3.3.3.3             impl-null   No     connected
                    E >     non-existent        none        No     connected
60.60.60.0/24       NL      4.4.4.4             impl-null   No     connected
                    E >     non-existent        none        No     connected

PE2#show ldp downstream
Session peer 1.1.1.1:
  FEC                 Nexthop Addr      State             Label       Req.ID      Attr
Session peer 2.2.2.2:
  FEC                 Nexthop Addr      State             Label       Req.ID      Attr
  40.40.40.0/24       connected         Established       impl-null   0
  20.20.20.0/24       connected         Established       25604       0
  10.12.49.0/24       connected         Established       impl-null   0
  10.10.10.0/24       40.40.40.1        Established       impl-null   0
  2.2.2.2/32          40.40.40.1        Established       impl-null   0
  1.1.1.1/32          40.40.40.1        Established       25601       0
Session peer 3.3.3.3:
  FEC                 Nexthop Addr      State             Label       Req.ID      Attr
  50.50.50.0/24       connected         Established       impl-null   0
  20.20.20.0/24       50.50.50.1        Established       impl-null   0
  10.12.49.0/24       connected         Established       impl-null   0
  3.3.3.3/32          50.50.50.1        Established       impl-null   0
  1.1.1.1/32          50.50.50.1        Established       25600       0
Session peer 4.4.4.4:
  FEC                 Nexthop Addr      State             Label       Req.ID      Attr
  60.60.60.0/24       connected         Established       impl-null   0
  30.30.30.0/24       60.60.60.1        Established       impl-null   0
  20.20.20.0/24       connected         Established       25605       0
  10.12.49.0/24       connected         Established       impl-null   0
  4.4.4.4/32          60.60.60.1        Established       impl-null   0
  1.1.1.1/32          60.60.60.1        Established       25600       0

PE2#show ldp lsp
DOWNSTREAM LSP :
  FEC                 Nexthop Addr      State             Label       Req.ID      Attr
  1.1.1.1/32          60.60.60.1        Established       25600       0
  1.1.1.1/32          50.50.50.1        Established       25600       0
  1.1.1.1/32          40.40.40.1        Established       25601       0
  2.2.2.2/32          40.40.40.1        Established       impl-null   0
  3.3.3.3/32          50.50.50.1        Established       impl-null   0
  4.4.4.4/32          60.60.60.1        Established       impl-null   0
  5.5.5.5/32          connected         Established       none        0           None
  10.10.10.0/24       40.40.40.1        Established       impl-null   0
```

```
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      impl-null   0
  10.12.49.0/24       connected        Established      none        0           None
  20.20.20.0/24       connected        Established      25605       0
  20.20.20.0/24       50.50.50.1       Established      impl-null   0
  20.20.20.0/24       connected        Established      25604       0
  30.30.30.0/24       60.60.60.1       Established      impl-null   0
  40.40.40.0/24       connected        Established      impl-null   0
  40.40.40.0/24       connected        Established      none        0           None
  50.50.50.0/24       connected        Established      impl-null   0
  50.50.50.0/24       connected        Established      none        0           None
  60.60.60.0/24       connected        Established      impl-null   0
  60.60.60.0/24       connected        Established      none        0           None

UPSTREAM LSP :
  FEC                 State            Label       Req.ID      Attr
  2.2.2.2/32          Established      25601       0           None
  2.2.2.2/32          Established      25608       0           None
  3.3.3.3/32          Established      25614       0           None
  3.3.3.3/32          Established      25609       0           None
  4.4.4.4/32          Established      25615       0           None
  4.4.4.4/32          Established      25603       0           None
  5.5.5.5/32          Established      impl-null   0           None
  5.5.5.5/32          Established      impl-null   0           None
  5.5.5.5/32          Established      impl-null   0           None
  10.10.10.0/24       Established      25604       0           None
  10.10.10.0/24       Established      25611       0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  10.12.49.0/24       Established      impl-null   0           None
  20.20.20.0/24       Established      25616       0           None
  20.20.20.0/24       Established      25616       0           None
  20.20.20.0/24       Established      25612       0           None
  20.20.20.0/24       Established      25612       0           None
  30.30.30.0/24       Established      25617       0           None
  30.30.30.0/24       Established      25606       0           None
  40.40.40.0/24       Established      impl-null   0           None
  40.40.40.0/24       Established      impl-null   0           None
  40.40.40.0/24       Established      impl-null   0           None
  50.50.50.0/24       Established      impl-null   0           None
  50.50.50.0/24       Established      impl-null   0           None
  50.50.50.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None
  60.60.60.0/24       Established      impl-null   0           None

PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
```

```
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         1        1         -          Yes   LSP_DEFAULT  25601
xe1        No    40.40.40.1
                                   7         -          Yes   LSP_DEFAULT  25600
xe3       No    60.60.60.1
                                   8         -          Yes   LSP_DEFAULT  25600
xe2        No    50.50.50.1
   L>   2.2.2.2/32         2        2         -          Yes   LSP_DEFAULT  3
xe1        No    40.40.40.1
   L>   3.3.3.3/32         3        9         -          Yes   LSP_DEFAULT  3
xe2        No    50.50.50.1
   L>   4.4.4.4/32         4        10        -          Yes   LSP_DEFAULT  3
xe3       No    60.60.60.1
   L>   10.10.10.0/24      5        2         -          Yes   LSP_DEFAULT  3
xe1        No    40.40.40.1
   L>   20.20.20.0/24      6        9         -          Yes   LSP_DEFAULT  3
xe2        No    50.50.50.1
   L>   30.30.30.0/24      7        10        -          Yes   LSP_DEFAULT  3
xe3       No    60.60.60.1

PE2#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop

PE2#show mpls forwarding-table 1.1.1.1/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         1        1         -          Yes   LSP_DEFAULT  25601
xe1        No    40.40.40.1
                                   7         -          Yes   LSP_DEFAULT  25600
xe3       No    60.60.60.1
                                   8         -          Yes   LSP_DEFAULT  25600
xe2        No    50.50.50.1

PE2#show mpls ftn-table
 Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
```

```
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
    Nexthop addr: 40.40.40.1        cross connect ix: 1, op code: Push

     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 60.60.60.1        cross connect ix: 1, op code: Push

     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
    Nexthop addr: 50.50.50.1        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 2.2.2.2/32, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 40.40.40.1        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 50.50.50.1        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 60.60.60.1        cross connect ix: 8, op code: Push


 Primary FTN entry with FEC: 10.10.10.0/24, id: 5, row status: Active, Tunnel-Policy: N/
A
```

```
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 40.40.40.1        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 20.20.20.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 50.50.50.1        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 30.30.30.0/24, id: 7, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 10
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 60.60.60.1        cross connect ix: 8, op code: Push


PE2#show mpls ftn-table 1.1.1.1/32
 Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
    Nexthop addr: 40.40.40.1        cross connect ix: 1, op code: Push

     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 60.60.60.1        cross connect ix: 1, op code: Push

     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
```

```
      Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
    Nexthop addr: 50.50.50.1        cross connect ix: 1, op code: Push

PE2#show ldp fec prefix 1.1.1.1/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          NL>     4.4.4.4             25600       No    60.60.60.1
                    NL>     3.3.3.3             25600       No    50.50.50.1
                    NL>     2.2.2.2             25601       No    40.40.40.1
```

RTR1 - FRR Configuration

Now that NSM, ISIS and LDP are all configured, FRR for IGP and LDP can be enabled using below configurations.

`#configure terminal`	Enter configuration mode.
`(config)#router isis 1`	Create an IS-IS routing instance for area 49 with instance 1
`(config-router)#fast-reroute per-prefix level-1 proto ipv4 all`	Configure LFA-FRR to calculate the available backup path for all L1 ipv4 prefixes learnt
`(config-router)#exit`	Exit router mode.
`(config)#router ldp`	Enter router mode for LDP.
`(config-router)#fast-reroute`	Configure LDP LFA-FRR to calculate the available backup path
`(config-router)#exit`	Exit router mode.
`(config)#commit`	Commit all the configurations

Validation

```
PE1#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P1             xe1          5254.0002.5b0a      Up     28        L1   IS-IS
P2             xe2         5254.009b.f9a2      Up     7         L1   IS-IS
P3             xe3         5254.005d.e995      Up     5         L1   IS-IS

PE1#show clns neighbors detail

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
```

```
P1              xe1        5254.0002.5b0a      Up     22        L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:50:07
  Area Address(es): 49.0001
  IP Address(es): 10.10.10.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P2              xe2       5254.009b.f9a2      Up     7         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:49:43
  Area Address(es): 49.0001
  IP Address(es): 20.20.20.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P3              xe3       5254.005d.e995      Up     5         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:49:18
  Area Address(es): 49.0001
  IP Address(es): 30.30.30.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise

PE1#show isis database
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00           * 0x0000000D   0xD5A2        956               0/0/0
PE1.02-00           * 0x00000004   0x8246        895               0/0/0
P1.00-00              0x0000000B   0xBC5A        1023              0/0/0
P1.03-00              0x00000004   0xB80A        982               0/0/0
P2.00-00              0x0000000A   0xFC55        1027              0/0/0
P2.02-00              0x00000004   0x7055        918               0/0/0
P2.03-00              0x00000004   0xB907        1012              0/0/0
P3.00-00              0x0000000A   0xDBB1        1047              0/0/0
P3.02-00              0x00000004   0x7152        933               0/0/0
PE2.00-00             0x0000000D   0xDD02        1043              0/0/0
PE2.04-00             0x00000004   0xA01C        1042              0/0/0


PE1#show isis database verbose
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00           * 0x0000000D   0xD5A2        947               0/0/0
```

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```
Area Address: 49.0001
NLPID:        0xCC
Hostname:     PE1
IP Address:   1.1.1.1
Router ID:    10.12.49.172
Metric:   20         IS-Extended PE1.02
  IPv4 Interface Address: 10.10.10.1
  Neighbor IP Address: 10.10.10.1
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 20
Metric:   15         IS-Extended P2.02
  IPv4 Interface Address: 20.20.20.1
  Neighbor IP Address: 20.20.20.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 15
Metric:   60         IS-Extended P3.02
  IPv4 Interface Address: 30.30.30.1
  Neighbor IP Address: 30.30.30.2
  Maximum Link Bandwidth : 100000.00 kbits/sec
  Reservable Bandwidth : 100000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
  TE-Default Metric: 60
```

```
  Metric:   10         IP-Extended 1.1.1.1/32
  Metric:   20         IP-Extended 10.10.10.0/24
  Metric:   15         IP-Extended 20.20.20.0/24
  Metric:   60         IP-Extended 30.30.30.0/24
PE1.02-00           * 0x00000004   0x8246        887               0/0/0
  Metric:   0          IS-Extended PE1.00
  Metric:   0          IS-Extended P1.00
P1.00-00              0x0000000B   0xBC5A        1015              0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P1
  IP Address:   2.2.2.2
  Router ID:    10.12.49.173
  Metric:   10         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.2
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.1
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 2.2.2.2/32
  Metric:   10         IP-Extended 10.10.10.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
P1.03-00              0x00000004   0xB80A        974               0/0/0
  Metric:   0          IS-Extended P1.00
  Metric:   0          IS-Extended PE2.00
P2.00-00              0x0000000A   0xFC55        1018              0/0/0
```

```
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P2
  IP Address:   3.3.3.3
  Router ID:    10.12.49.176
  Metric:   10         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.2
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.1
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 3.3.3.3/32
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 20.20.20.0/24
P2.02-00              0x00000004   0x7055        910               0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE1.00
P2.03-00              0x00000004   0xB907        1004              0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE2.00
P3.00-00              0x0000000A   0xDBB1        1039              0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P3
  IP Address:   4.4.4.4
  Router ID:    10.12.49.177
```

```
  Metric:   10         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.2
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.1
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 4.4.4.4/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 30.30.30.0/24
P3.02-00             0x00000004   0x7152        925               0/0/0
  Metric:   0          IS-Extended P3.00
  Metric:   0          IS-Extended PE1.00
PE2.00-00            0x0000000D   0xDD02        1035              0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE2
  IP Address:   5.5.5.5
  Router ID:    10.12.49.174
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.2
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
```

```
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.2
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.2
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 5.5.5.5/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
PE2.04-00            0x00000004   0xA01C        1034             0/0/0
  Metric:   0          IS-Extended PE2.00
  Metric:   0          IS-Extended P3.00


PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                   xe3      Passive   OPERATIONAL   30    00:48:09
2.2.2.2                   xe1       Passive   OPERATIONAL   30    00:50:11
```

```
3.3.3.3                    xe2      Passive   OPERATIONAL   30    00:49:23
4.4.4.4                    xe3      Passive   OPERATIONAL   30    00:49:30

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C             1.1.1.1/32 is directly connected, lo, 00:58:19
i L1          2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:50:20
i L1          3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:48:50
i L1          4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:47:10
i L1          5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:48:00
C             10.10.10.0/24 is directly connected, xe1, 00:58:19
C             10.12.49.0/24 is directly connected, xe0, 01:02:58
C             20.20.20.0/24 is directly connected, xe2, 00:58:19
C             30.30.30.0/24 is directly connected, xe3, 00:58:19
i L1          40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:48:00
i L1          50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:48:00
i L1          60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:48:00
C             127.0.0.0/8 is directly connected, lo, 03:34:09

PE1#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
isis            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 0
 Total number of IPv4 ECMP paths  : 0
```

```
 LFA Non ECMP statistics
 --------------
 Total number of Routes        : 7
 Total number of Primary Paths : 7
 Total number of Backup Paths  : 7

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
xe0                 *10.12.49.172    up                    up
xe1                  unassigned      up                    up
xe1                  10.10.10.1      up                    up
xe3                  unassigned      up                    up
xe4                  unassigned      up                    up
xe5                  unassigned      up                    up
xe6                  unassigned      up                    up
xe7                  unassigned      up                    up
xe8                  unassigned      up                    up
xe9                  unassigned      up                    up
xe10                 unassigned      up                    up
xe11                 unassigned      up                    up
xe2                 20.20.20.1      up                    up
xe3                 30.30.30.1      up                    up
lo                    127.0.0.1       up                    up

PE1#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

L1  2.2.2.2/32
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 20.20.20.2, xe2
    FRR Metric          : 45
    Protection Provided : LP BP

L1  3.3.3.3/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP BP

L1  4.4.4.4/32
    Primary Path via    : 20.20.20.2, xe2
```

```
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP NP BP DP

L1  5.5.5.5/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  40.40.40.0/24
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 20.20.20.2, xe2
    FRR Metric          : 35
    Protection Provided : LP NP BP DP

L1  50.50.50.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  60.60.60.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0         -                -               kernel
1.1.1.1/32          0.0.0.0          lo          -                -            connected
2.2.2.2/32          10.10.10.2       xe1         20.20.20.2       xe2              isis
3.3.3.3/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
4.4.4.4/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
5.5.5.5/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
10.10.10.0/24       0.0.0.0          xe1         -                -            connected
10.12.49.0/24       0.0.0.0          xe0         -                -            connected
20.20.20.0/24       0.0.0.0          xe2         -                -            connected
30.30.30.0/24       0.0.0.0          xe3         -                -            connected
40.40.40.0/24       10.10.10.2       xe1         20.20.20.2       xe2              isis
50.50.50.0/24       20.20.20.2       xe2         10.10.10.2       xe1              isis
60.60.60.0/24       20.20.20.2       xe2         10.10.10.2       xe1              isis


PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
```

```
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label    ELC    Nexthop Addr
1.1.1.1/32          E >     non-existent        none         No     connected
2.2.2.2/32          NL      4.4.4.4             25608        No     no nexthop
                    NLB>    3.3.3.3             25608        No     20.20.20.2
                    NLP>    2.2.2.2             impl-null    No     10.10.10.2
3.3.3.3/32          NLB>    2.2.2.2             25608        No     10.10.10.2
                    NL      4.4.4.4             25609        No     no nexthop
                    NLP>    3.3.3.3             impl-null    No     20.20.20.2
4.4.4.4/32          NLB>    2.2.2.2             25609        No     10.10.10.2
                    NLP>    3.3.3.3             25609        No     20.20.20.2
                    NL      4.4.4.4             impl-null    No     no nexthop
5.5.5.5/32          NL      4.4.4.4             25610        No     no nexthop
                    NLP>    3.3.3.3             25610        No     20.20.20.2
                    NLB>    2.2.2.2             25600        No     10.10.10.2
10.10.10.0/24       NL      2.2.2.2             impl-null    No     connected
                    E >     non-existent        none         No     connected
10.12.49.0/24       NL      3.3.3.3             impl-null    No     connected
                    NL      4.4.4.4             impl-null    No     connected
                    NL      2.2.2.2             impl-null    No     connected
                    E >     non-existent        none         No     connected
20.20.20.0/24       NL      3.3.3.3             impl-null    No     connected
                    E >     non-existent        none         No     connected
30.30.30.0/24       NL      2.2.2.2             25610        No     connected
                    NL      3.3.3.3             25611        No     connected
                    NL      4.4.4.4             impl-null    No     connected
                    E >     non-existent        none         No     connected
40.40.40.0/24       NL      4.4.4.4             25611        No     no nexthop
                    NLB>    3.3.3.3             25612        No     20.20.20.2
                    NLP>    2.2.2.2             impl-null    No     10.10.10.2
50.50.50.0/24       NLB>    2.2.2.2             25611        No     10.10.10.2
                    NL      4.4.4.4             25612        No     no nexthop
                    NLP>    3.3.3.3             impl-null    No     20.20.20.2
60.60.60.0/24       NLB>    2.2.2.2             25612        No     10.10.10.2
                    NLP>    3.3.3.3             25613        No     20.20.20.2
                    NL      4.4.4.4             impl-null    No     no nexthop
PE1#show ldp downstream
Codes: P - Primary route, B - Backup route
Session peer 5.5.5.5:
  FEC                 Nexthop Addr    State          Label      Req.ID     Attr
Code
Codes: P - Primary route, B - Backup route
Session peer 2.2.2.2:
  FEC                 Nexthop Addr    State          Label      Req.ID     Attr
Code
   60.60.60.0/24       connected        Established      25612       0
  60.60.60.0/24      10.10.10.2     Established     25612      0
B
   50.50.50.0/24       connected        Established      25611       0
  50.50.50.0/24      10.10.10.2     Established     25611      0
B
```

```
  30.30.30.0/24       connected       Established      25610       0
  4.4.4.4/32          connected       Established      25609       0
 4.4.4.4/32        10.10.10.2     Established    25609      0
B
  3.3.3.3/32          connected       Established      25608       0
 3.3.3.3/32        10.10.10.2     Established    25608      0
B
  5.5.5.5/32          connected       Established      25600       0
 5.5.5.5/32        10.10.10.2     Established    25600      0
B
 40.40.40.0/24      10.10.10.2     Established    impl-null   0
P
  10.12.49.0/24       connected       Established      impl-null   0
  10.10.10.0/24       connected       Established      impl-null   0
 2.2.2.2/32        10.10.10.2     Established    impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 3.3.3.3:
 FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
  40.40.40.0/24       connected       Established      25612       0
 40.40.40.0/24      20.20.20.2     Established    25612      0
B
  30.30.30.0/24       connected       Established      25611       0
 4.4.4.4/32        20.20.20.2     Established    25609      0
P
  2.2.2.2/32          connected       Established      25608       0
 2.2.2.2/32        20.20.20.2     Established    25608      0
B
 60.60.60.0/24      20.20.20.2     Established    25613      0
P
 5.5.5.5/32        20.20.20.2     Established    25610      0
P
 50.50.50.0/24      20.20.20.2     Established    impl-null   0
P
  20.20.20.0/24       connected       Established      impl-null   0
  10.12.49.0/24       connected       Established      impl-null   0
 3.3.3.3/32        20.20.20.2     Established    impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 4.4.4.4:
 FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
  50.50.50.0/24       connected       Established      25612       0
  40.40.40.0/24       connected       Established      25611       0
  5.5.5.5/32          connected       Established      25610       0
  3.3.3.3/32          connected       Established      25609       0
  2.2.2.2/32          connected       Established      25608       0
  60.60.60.0/24       connected       Established      impl-null   0
  30.30.30.0/24       connected       Established      impl-null   0
  10.12.49.0/24       connected       Established      impl-null   0
  4.4.4.4/32          connected       Established      impl-null   0
```

```
PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC                 Nexthop Addr    State           Label      Req.ID     Attr
Code
  1.1.1.1/32          connected       Established     none       0          None
  2.2.2.2/32          connected       Established     25608      0
  2.2.2.2/32          connected       Established     25608      0
  2.2.2.2/32        20.20.20.2      Established     25608      0
B
  2.2.2.2/32        10.10.10.2      Established     impl-null  0
P
  3.3.3.3/32          connected       Established     25608      0
  3.3.3.3/32        10.10.10.2      Established     25608      0
B
  3.3.3.3/32          connected       Established     25609      0
  3.3.3.3/32        20.20.20.2      Established     impl-null  0
P
  4.4.4.4/32          connected       Established     25609      0
  4.4.4.4/32        10.10.10.2      Established     25609      0
B
  4.4.4.4/32        20.20.20.2      Established     25609      0
P
  4.4.4.4/32          connected       Established     impl-null  0
  5.5.5.5/32          connected       Established     25610      0
  5.5.5.5/32        20.20.20.2      Established     25610      0
P
  5.5.5.5/32          connected       Established     25600      0
  5.5.5.5/32        10.10.10.2      Established     25600      0
B
  10.10.10.0/24       connected       Established     impl-null  0
  10.10.10.0/24       connected       Established     none       0          None
  10.12.49.0/24       connected       Established     impl-null  0
  10.12.49.0/24       connected       Established     impl-null  0
  10.12.49.0/24       connected       Established     impl-null  0
  10.12.49.0/24       connected       Established     none       0          None
  20.20.20.0/24       connected       Established     impl-null  0
  20.20.20.0/24       connected       Established     none       0          None
  30.30.30.0/24       connected       Established     25610      0
  30.30.30.0/24       connected       Established     25611      0
  30.30.30.0/24       connected       Established     impl-null  0
  30.30.30.0/24       connected       Established     none       0          None
  40.40.40.0/24       connected       Established     25611      0
  40.40.40.0/24       connected       Established     25612      0
  40.40.40.0/24     20.20.20.2      Established     25612      0
B
  40.40.40.0/24     10.10.10.2      Established     impl-null  0
P
  50.50.50.0/24       connected       Established     25611      0
  50.50.50.0/24     10.10.10.2      Established     25611      0
B
  50.50.50.0/24       connected       Established     25612      0
  50.50.50.0/24     20.20.20.2      Established     impl-null  0
P
```

```
  60.60.60.0/24       connected        Established      25612       0
  60.60.60.0/24      10.10.10.2     Established     25612      0
B
  60.60.60.0/24      20.20.20.2     Established     25613      0
P
  60.60.60.0/24       connected        Established      impl-null   0

UPSTREAM LSP :
  FEC                 State            Label        Req.ID       Attr
  1.1.1.1/32          Established      impl-null    0            None
  1.1.1.1/32          Established      impl-null    0            None
  1.1.1.1/32          Established      impl-null    0            None
  2.2.2.2/32          Established      25604        0            None
  2.2.2.2/32          Established      25604        0            None
  2.2.2.2/32          Established      25608        0            None
  3.3.3.3/32          Established      25605        0            None
  3.3.3.3/32          Established      25605        0            None
  3.3.3.3/32          Established      25600        0            None
  4.4.4.4/32          Established      25603        0            None
  4.4.4.4/32          Established      25602        0            None
  4.4.4.4/32          Established      25603        0            None
  4.4.4.4/32          Established      25602        0            None
  5.5.5.5/32          Established      25614        0            None
  5.5.5.5/32          Established      25615        0            None
  5.5.5.5/32          Established      25615        0            None
  10.10.10.0/24       Established      impl-null    0            None
  10.10.10.0/24       Established      impl-null    0            None
  10.10.10.0/24       Established      impl-null    0            None
  10.12.49.0/24       Established      impl-null    0            None
  10.12.49.0/24       Established      impl-null    0            None
  10.12.49.0/24       Established      impl-null    0            None
  20.20.20.0/24       Established      impl-null    0            None
  20.20.20.0/24       Established      impl-null    0            None
  20.20.20.0/24       Established      impl-null    0            None
  30.30.30.0/24       Established      impl-null    0            None
  30.30.30.0/24       Established      impl-null    0            None
  30.30.30.0/24       Established      impl-null    0            None
  40.40.40.0/24       Established      25606        0            None
  40.40.40.0/24       Established      25606        0            None
  40.40.40.0/24       Established      25610        0            None
  50.50.50.0/24       Established      25607        0            None
  50.50.50.0/24       Established      25607        0            None
  50.50.50.0/24       Established      25601        0            None
  60.60.60.0/24       Established      25616        0            None
  60.60.60.0/24       Established      25616        0            None
  60.60.60.0/24       Established      25617        0            None
  60.60.60.0/24       Established      25617        0            None

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
```

```
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1        1         -          Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                    2         -          No    LSP_DEFAULT  25608
xe2        No    20.20.20.2
   L>   3.3.3.3/32         5        3         -          Yes   LSP_DEFAULT  3
xe2        No    20.20.20.2
                                    4         -          No    LSP_DEFAULT  25608
xe1         No    10.10.10.2
   L>   4.4.4.4/32         3        7         -          Yes   LSP_DEFAULT  25609
xe2        No    20.20.20.2
                                    8         -          No    LSP_DEFAULT  25609
xe1         No    10.10.10.2
   L>   5.5.5.5/32         7        5         -          Yes   LSP_DEFAULT  25610
xe2        No    20.20.20.2
                                    9         -          No    LSP_DEFAULT  25600
xe1         No    10.10.10.2
   L>   40.40.40.0/24      2        1         -          Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                    10        -          No    LSP_DEFAULT  25612
xe2        No    20.20.20.2
   L>   50.50.50.0/24      6        3         -          Yes   LSP_DEFAULT  3
xe2        No    20.20.20.2
                                    11        -          No    LSP_DEFAULT  25611
xe1         No    10.10.10.2
   L>   60.60.60.0/24      4        6         -          Yes   LSP_DEFAULT  25613
xe2        No    20.20.20.2
                                    12        -          No    LSP_DEFAULT  25612
xe1         No    10.10.10.2
PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        5         -          Yes   LSP_DEFAULT  25610
xe2        No    20.20.20.2
                                    9         -          No    LSP_DEFAULT  25600
xe1         No    10.10.10.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
```

```
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 2
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe2, out label: 25608
    Nexthop addr: 20.20.20.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
    Nexthop addr: 10.10.10.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 5, in intf: - in label: 0  out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
```

```
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 9, in intf: - in label: 0  out-segment ix: 10
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe2, out label: 25612
    Nexthop addr: 20.20.20.2        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 11, in intf: - in label: 0  out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611
    Nexthop addr: 10.10.10.2        cross connect ix: 11, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613
    Nexthop addr: 20.20.20.2        cross connect ix: 6, op code: Push

     Backup Cross connect ix: 13, in intf: - in label: 0  out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
    Nexthop addr: 10.10.10.2        cross connect ix: 13, op code: Push


PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NLP>    3.3.3.3             25610       No    20.20.20.2
                    NLB>    2.2.2.2             25600       No    10.10.10.2

PE1#show ip route fast-reroute
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p - 
stale info, E - EVPN
       * - candidate default

IP Route Table for VRF "default"
i L1    2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:52:13
                   [FRR-NH] via 20.20.20.2, xe2

i L1    3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:50:43
                   [FRR-NH] via 10.10.10.2, xe1

i L1    4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:49:03
                   [FRR-NH] via 10.10.10.2, xe1
```

```
i L1    5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:49:53
                   [FRR-NH] via 10.10.10.2, xe1

i L1    40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:49:53
                      [FRR-NH] via 20.20.20.2, xe2

i L1    50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:49:53
                      [FRR-NH] via 10.10.10.2, xe1

i L1    60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:49:53
                      [FRR-NH] via 10.10.10.2, xe1

PE1#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

L1  2.2.2.2/32
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 20.20.20.2, xe2
    FRR Metric          : 45
    Protection Provided : LP BP

L1  3.3.3.3/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP BP

L1  4.4.4.4/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP NP BP DP

L1  5.5.5.5/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  40.40.40.0/24
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 20.20.20.2, xe2
    FRR Metric          : 35
    Protection Provided : LP NP BP DP
```

```
L1  50.50.50.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  60.60.60.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0         -                -                kernel
1.1.1.1/32          0.0.0.0          lo          -                -                connected
2.2.2.2/32          10.10.10.2       xe1         20.20.20.2       xe2              isis
3.3.3.3/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
4.4.4.4/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
5.5.5.5/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
10.10.10.0/24       0.0.0.0          xe1         -                -                connected
10.12.49.0/24       0.0.0.0          xe0         -                -                connected
20.20.20.0/24       0.0.0.0          xe2         -                -                connected
30.30.30.0/24       0.0.0.0          xe3         -                -                connected
40.40.40.0/24       10.10.10.2       xe1         20.20.20.2       xe2              isis
50.50.50.0/24       20.20.20.2       xe2         10.10.10.2       xe1              isis
60.60.60.0/24       20.20.20.2       xe2         10.10.10.2       xe1              isis

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32        1         1         -           Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                    2         -           No    LSP_DEFAULT  25608
xe2         No    20.20.20.2
   L>   3.3.3.3/32        5         3         -           Yes   LSP_DEFAULT  3
xe2         No    20.20.20.2
                                    4         -           No    LSP_DEFAULT  25608
xe1         No    10.10.10.2
   L>   4.4.4.4/32        3         7         -           Yes   LSP_DEFAULT  25609
xe2         No    20.20.20.2
                                    8         -           No    LSP_DEFAULT  25609
xe1         No    10.10.10.2
   L>   5.5.5.5/32        7         5         -           Yes   LSP_DEFAULT  25610
xe2         No    20.20.20.2
                                    9         -           No    LSP_DEFAULT  25600
xe1         No    10.10.10.2
```

```
   L>   40.40.40.0/24      2        1        -          Yes   LSP_DEFAULT  3
xe1        No    10.10.10.2
                                    10       -          No    LSP_DEFAULT  25612
xe2       No    20.20.20.2
   L>   50.50.50.0/24      6        3        -          Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
                                    11       -          No    LSP_DEFAULT  25611
xe1        No    10.10.10.2
   L>   60.60.60.0/24      4        6        -          Yes   LSP_DEFAULT  25613
xe2       No    20.20.20.2
                                    12       -          No    LSP_DEFAULT  25612
xe1        No    10.10.10.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        5        -          Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
                                    9        -          No    LSP_DEFAULT  25600
xe1        No    10.10.10.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 2
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe2, out label: 25608
    Nexthop addr: 20.20.20.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push
```

```
     Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
    Nexthop addr: 10.10.10.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 5, in intf: - in label: 0  out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 9, in intf: - in label: 0  out-segment ix: 10
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
       Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe2, out label: 25612
    Nexthop addr: 20.20.20.2        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 11, in intf: - in label: 0  out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611
    Nexthop addr: 10.10.10.2        cross connect ix: 11, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613
    Nexthop addr: 20.20.20.2        cross connect ix: 6, op code: Push

     Backup Cross connect ix: 13, in intf: - in label: 0  out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
    Nexthop addr: 10.10.10.2        cross connect ix: 13, op code: Push


PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push

PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label    ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610        No    no nexthop
                    NLP>    3.3.3.3             25610        No    20.20.20.2
                    NLB>    2.2.2.2             25600        No    10.10.10.2
```

To prohibit an interface from being used as a repair path, disable fast reroute calculation on the interface:

`#configure terminal`	Enter configuration mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#isis fast-reroute per-prefix candidate disable level-1`	Disable fast reroute calculation on the interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit all the configurations

Verify that the xe1 interface is not used for backup path calculation.

```
PE1#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P1             xe1          5254.0002.5b0a      Up     22        L1   IS-IS
P2             xe2         5254.009b.f9a2      Up     8         L1   IS-IS
P3             xe3         5254.005d.e995      Up     6         L1   IS-IS

PE1#show clns neighbors detail

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P1             xe1          5254.0002.5b0a      Up     20        L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:57:18
  Area Address(es): 49.0001
  IP Address(es): 10.10.10.2
```

```
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P2              xe2       5254.009b.f9a2      Up     6         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:56:54
  Area Address(es): 49.0001
  IP Address(es): 20.20.20.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P3              xe3       5254.005d.e995      Up     8         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 00:56:29
  Area Address(es): 49.0001
  IP Address(es): 30.30.30.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise

PE1#show isis database
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00           * 0x0000000D   0xD5A2        523               0/0/0
PE1.02-00           * 0x00000004   0x8246        462               0/0/0
P1.00-00              0x0000000B   0xBC5A        590               0/0/0
P1.03-00              0x00000004   0xB80A        549               0/0/0
P2.00-00              0x0000000A   0xFC55        593               0/0/0
P2.02-00              0x00000004   0x7055        485               0/0/0
P2.03-00              0x00000004   0xB907        579               0/0/0
P3.00-00              0x0000000A   0xDBB1        614               0/0/0
P3.02-00              0x00000004   0x7152        500               0/0/0
PE2.00-00             0x0000000D   0xDD02        610               0/0/0
PE2.04-00             0x00000004   0xA01C        609               0/0/0


PE1#show isis database verbose
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00           * 0x0000000D   0xD5A2        513               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE1
  IP Address:   1.1.1.1
  Router ID:    10.12.49.172
  Metric:   20         IS-Extended PE1.02
```

```
    IPv4 Interface Address: 10.10.10.1
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 20
  Metric:   15         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.1
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 15
  Metric:   60         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.1
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 60
  Metric:   10         IP-Extended 1.1.1.1/32
  Metric:   20         IP-Extended 10.10.10.0/24
  Metric:   15         IP-Extended 20.20.20.0/24
  Metric:   60         IP-Extended 30.30.30.0/24
PE1.02-00           * 0x00000004   0x8246        452                0/0/0
  Metric:   0          IS-Extended PE1.00
```

```
  Metric:   0          IS-Extended P1.00
P1.00-00              0x0000000B   0xBC5A        580               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P1
  IP Address:   2.2.2.2
  Router ID:    10.12.49.173
  Metric:   10         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.2
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.1
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 2.2.2.2/32
  Metric:   10         IP-Extended 10.10.10.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
P1.03-00              0x00000004   0xB80A        540               0/0/0
  Metric:   0          IS-Extended P1.00
  Metric:   0          IS-Extended PE2.00
P2.00-00              0x0000000A   0xFC55        584               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P2
  IP Address:   3.3.3.3
  Router ID:    10.12.49.176
  Metric:   10         IS-Extended P2.02
```

```
    IPv4 Interface Address: 20.20.20.2
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.1
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 3.3.3.3/32
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 20.20.20.0/24
P2.02-00              0x00000004   0x7055       476               0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE1.00
P2.03-00              0x00000004   0xB907       570               0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE2.00
P3.00-00              0x0000000A   0xDBB1       605               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P3
  IP Address:   4.4.4.4
  Router ID:    10.12.49.177
  Metric:   10         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.2
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
```

```
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.1
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 4.4.4.4/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 30.30.30.0/24
P3.02-00              0x00000004   0x7152        491               0/0/0
  Metric:   0          IS-Extended P3.00
  Metric:   0          IS-Extended PE1.00
PE2.00-00             0x0000000D   0xDD02        601               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE2
  IP Address:   5.5.5.5
  Router ID:    10.12.49.174
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.2
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.2
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.2
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 5.5.5.5/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
PE2.04-00             0x00000004   0xA01C        600               0/0/0
  Metric:   0          IS-Extended PE2.00
  Metric:   0          IS-Extended P3.00

PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                   xe3      Passive   OPERATIONAL   30    00:55:24
2.2.2.2                   xe1       Passive   OPERATIONAL   30    00:57:26
3.3.3.3                   xe2      Passive   OPERATIONAL   30    00:56:38
4.4.4.4                   xe3      Passive   OPERATIONAL   30    00:56:45

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
```

```
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C             1.1.1.1/32 is directly connected, lo, 01:06:01
i L1          2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:58:02
i L1          3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:56:32
i L1          4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:54:52
i L1          5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:55:42
C             10.10.10.0/24 is directly connected, xe1, 01:06:01
C             10.12.49.0/24 is directly connected, xe0, 01:10:40
C             20.20.20.0/24 is directly connected, xe2, 01:06:01
C             30.30.30.0/24 is directly connected, xe3, 01:06:01
i L1          40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:55:42
i L1          50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:55:42
i L1          60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:55:42
C             127.0.0.0/8 is directly connected, lo, 03:41:51


PE1#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
isis            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 0
 Total number of IPv4 ECMP paths  : 0

 LFA Non ECMP statistics
 --------------
 Total number of Routes        : 7
 Total number of Primary Paths : 7
 Total number of Backup Paths  : 7
```

```
PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
xe0                 *10.12.49.172    up                     up
xe1                  unassigned      up                     up
xe1                  10.10.10.1      up                     up
xe3                  unassigned      up                     up
xe4                  unassigned      up                     up
xe5                  unassigned      up                     up
xe6                  unassigned      up                     up
xe7                  unassigned      up                     up
xe8                  unassigned      up                     up
xe9                  unassigned      up                     up
xe10                 unassigned      up                     up
xe11                 unassigned      up                     up
xe2                 20.20.20.1      up                     up
xe3                 30.30.30.1      up                     up
lo                    127.0.0.1       up                     up

PE1#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

L1  2.2.2.2/32
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 30.30.30.2, xe3
    FRR Metric          : 90
    Protection Provided : LP BP

L1  3.3.3.3/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP BP

L1  4.4.4.4/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP NP BP DP

L1  5.5.5.5/32
```

```
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  40.40.40.0/24
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 30.30.30.2, xe3
    FRR Metric          : 80
    Protection Provided : LP NP BP DP

L1  50.50.50.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  60.60.60.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0         -                -                kernel
1.1.1.1/32          0.0.0.0          lo          -                -                connected
2.2.2.2/32          10.10.10.2       xe1         30.30.30.2       xe3              isis
3.3.3.3/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
4.4.4.4/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
5.5.5.5/32          20.20.20.2       xe2         10.10.10.2       xe1              isis
10.10.10.0/24       0.0.0.0          xe1         -                -                connected
10.12.49.0/24       0.0.0.0          xe0         -                -                connected
20.20.20.0/24       0.0.0.0          xe2         -                -                connected
30.30.30.0/24       0.0.0.0          xe3         -                -                connected
40.40.40.0/24       10.10.10.2       xe1         30.30.30.2       xe3              isis
50.50.50.0/24       20.20.20.2       xe2         10.10.10.2       xe1              isis
60.60.60.0/24       20.20.20.2       xe2         10.10.10.2       xe1              isis

PE1#show ldp fec
LSR codes     : E/N - LSR is egress/non-egress for this FEC,
                L - LSR received a label for this FEC,
                P - Primary route, B - LFA Backup route,
                R - Remote LFA Backup route,
                > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label    ELC   Nexthop Addr
1.1.1.1/32          E >     non-existent        none         No    connected
2.2.2.2/32          NLB>    4.4.4.4             25608        No    30.30.30.2
                    NL      3.3.3.3             25608        No    no nexthop
                    NLP>    2.2.2.2             impl-null    No    10.10.10.2
```

```
3.3.3.3/32          NLB>    2.2.2.2             25608       No    10.10.10.2
                    NL      4.4.4.4             25609       No    no nexthop
                    NLP>    3.3.3.3             impl-null   No    20.20.20.2
4.4.4.4/32          NLB>    2.2.2.2             25609       No    10.10.10.2
                    NLP>    3.3.3.3             25609       No    20.20.20.2
                    NL      4.4.4.4             impl-null   No    no nexthop
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NLP>    3.3.3.3             25610       No    20.20.20.2
                    NLB>    2.2.2.2             25600       No    10.10.10.2
10.10.10.0/24       NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
10.12.49.0/24       NL      3.3.3.3             impl-null   No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL      3.3.3.3             impl-null   No    connected
                    E >     non-existent        none        No    connected
30.30.30.0/24       NL      2.2.2.2             25610       No    connected
                    NL      3.3.3.3             25611       No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    E >     non-existent        none        No    connected
40.40.40.0/24       NLB>    4.4.4.4             25611       No    30.30.30.2
                    NL      3.3.3.3             25612       No    no nexthop
                    NLP>    2.2.2.2             impl-null   No    10.10.10.2
50.50.50.0/24       NLB>    2.2.2.2             25611       No    10.10.10.2
                    NL      4.4.4.4             25612       No    no nexthop
                    NLP>    3.3.3.3             impl-null   No    20.20.20.2
60.60.60.0/24       NLB>    2.2.2.2             25612       No    10.10.10.2
                    NLP>    3.3.3.3             25613       No    20.20.20.2
                    NL      4.4.4.4             impl-null   No    no nexthop

PE1#show ldp downstream
Codes: P - Primary route, B - Backup route
Session peer 5.5.5.5:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
Codes: P - Primary route, B - Backup route
Session peer 2.2.2.2:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
  60.60.60.0/24       connected        Established      25612       0
  60.60.60.0/24      10.10.10.2     Established     25612      0
B
  50.50.50.0/24       connected        Established      25611       0
  50.50.50.0/24      10.10.10.2     Established     25611      0
B
  30.30.30.0/24       connected        Established      25610       0
  4.4.4.4/32          connected        Established      25609       0
  4.4.4.4/32         10.10.10.2     Established     25609      0
B
  3.3.3.3/32          connected        Established      25608       0
```

```
  3.3.3.3/32        10.10.10.2     Established     25608      0
B
   5.5.5.5/32          connected        Established      25600       0
  5.5.5.5/32        10.10.10.2     Established     25600      0
B
  40.40.40.0/24     10.10.10.2     Established     impl-null   0
P
   10.12.49.0/24       connected        Established      impl-null   0
   10.10.10.0/24       connected        Established      impl-null   0
  2.2.2.2/32        10.10.10.2     Established     impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 3.3.3.3:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
   40.40.40.0/24       connected        Established      25612       0
   30.30.30.0/24       connected        Established      25611       0
  4.4.4.4/32        20.20.20.2     Established     25609      0
P
   2.2.2.2/32          connected        Established      25608       0
  60.60.60.0/24     20.20.20.2     Established     25613      0
P
  5.5.5.5/32        20.20.20.2     Established     25610      0
P
  50.50.50.0/24     20.20.20.2     Established     impl-null   0
P
   20.20.20.0/24       connected        Established      impl-null   0
   10.12.49.0/24       connected        Established      impl-null   0
  3.3.3.3/32        20.20.20.2     Established     impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 4.4.4.4:
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
   50.50.50.0/24       connected        Established      25612       0
   40.40.40.0/24       connected        Established      25611       0
  40.40.40.0/24     30.30.30.2     Established     25611      0
B
   5.5.5.5/32          connected        Established      25610       0
   3.3.3.3/32          connected        Established      25609       0
   2.2.2.2/32          connected        Established      25608       0
  2.2.2.2/32        30.30.30.2     Established     25608      0
B
   60.60.60.0/24       connected        Established      impl-null   0
   30.30.30.0/24       connected        Established      impl-null   0
   10.12.49.0/24       connected        Established      impl-null   0
   4.4.4.4/32          connected        Established      impl-null   0

PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC               Nexthop Addr    State          Label      Req.ID     Attr
Code
   1.1.1.1/32          connected        Established      none        0            None
   2.2.2.2/32          connected        Established      25608       0
```

```
 2.2.2.2/32        30.30.30.2     Established    25608     0
B
  2.2.2.2/32         connected       Established     25608       0
 2.2.2.2/32        10.10.10.2     Established    impl-null  0
P
  3.3.3.3/32         connected       Established     25608       0
 3.3.3.3/32        10.10.10.2     Established    25608     0
B
  3.3.3.3/32         connected       Established     25609       0
 3.3.3.3/32        20.20.20.2     Established    impl-null  0
P
  4.4.4.4/32         connected       Established     25609       0
 4.4.4.4/32        10.10.10.2     Established    25609     0
B
 4.4.4.4/32        20.20.20.2     Established    25609     0
P
  4.4.4.4/32         connected       Established     impl-null   0
  5.5.5.5/32         connected       Established     25610       0
 5.5.5.5/32        20.20.20.2     Established    25610     0
P
  5.5.5.5/32         connected       Established     25600       0
 5.5.5.5/32        10.10.10.2     Established    25600     0
B
  10.10.10.0/24      connected       Established     impl-null   0
  10.10.10.0/24      connected       Established     none        0          None
  10.12.49.0/24      connected       Established     impl-null   0
  10.12.49.0/24      connected       Established     impl-null   0
  10.12.49.0/24      connected       Established     impl-null   0
  10.12.49.0/24      connected       Established     none        0          None
  20.20.20.0/24      connected       Established     impl-null   0
  20.20.20.0/24      connected       Established     none        0          None
  30.30.30.0/24      connected       Established     25610       0
  30.30.30.0/24      connected       Established     25611       0
  30.30.30.0/24      connected       Established     impl-null   0
  30.30.30.0/24      connected       Established     none        0          None
  40.40.40.0/24      connected       Established     25611       0
 40.40.40.0/24     30.30.30.2     Established    25611     0
B
  40.40.40.0/24      connected       Established     25612       0
 40.40.40.0/24     10.10.10.2     Established    impl-null  0
P
  50.50.50.0/24      connected       Established     25611       0
 50.50.50.0/24     10.10.10.2     Established    25611     0
B
  50.50.50.0/24      connected       Established     25612       0
 50.50.50.0/24     20.20.20.2     Established    impl-null  0
P
  60.60.60.0/24      connected       Established     25612       0
 60.60.60.0/24     10.10.10.2     Established    25612     0
B
 60.60.60.0/24     20.20.20.2     Established    25613     0
P
  60.60.60.0/24      connected       Established     impl-null   0
```

```
UPSTREAM LSP :
  FEC                 State            Label        Req.ID       Attr
  1.1.1.1/32          Established      impl-null    0            None
  1.1.1.1/32          Established      impl-null    0            None
  1.1.1.1/32          Established      impl-null    0            None
  2.2.2.2/32          Established      25608        0            None
  2.2.2.2/32          Established      25604        0            None
  2.2.2.2/32          Established      25604        0            None
  2.2.2.2/32          Established      25608        0            None
  3.3.3.3/32          Established      25605        0            None
  3.3.3.3/32          Established      25605        0            None
  3.3.3.3/32          Established      25600        0            None
  4.4.4.4/32          Established      25603        0            None
  4.4.4.4/32          Established      25602        0            None
  4.4.4.4/32          Established      25603        0            None
  4.4.4.4/32          Established      25602        0            None
  5.5.5.5/32          Established      25614        0            None
  5.5.5.5/32          Established      25615        0            None
  5.5.5.5/32          Established      25615        0            None
  10.10.10.0/24       Established      impl-null    0            None
  10.10.10.0/24       Established      impl-null    0            None
  10.10.10.0/24       Established      impl-null    0            None
  10.12.49.0/24       Established      impl-null    0            None
  10.12.49.0/24       Established      impl-null    0            None
  10.12.49.0/24       Established      impl-null    0            None
  20.20.20.0/24       Established      impl-null    0            None
  20.20.20.0/24       Established      impl-null    0            None
  20.20.20.0/24       Established      impl-null    0            None
  30.30.30.0/24       Established      impl-null    0            None
  30.30.30.0/24       Established      impl-null    0            None
  30.30.30.0/24       Established      impl-null    0            None
  40.40.40.0/24       Established      25610        0            None
  40.40.40.0/24       Established      25606        0            None
  40.40.40.0/24       Established      25606        0            None
  40.40.40.0/24       Established      25610        0            None
  50.50.50.0/24       Established      25607        0            None
  50.50.50.0/24       Established      25607        0            None
  50.50.50.0/24       Established      25601        0            None
  60.60.60.0/24       Established      25616        0            None
  60.60.60.0/24       Established      25616        0            None
  60.60.60.0/24       Established      25617        0            None
  60.60.60.0/24       Established      25617        0            None

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
```

```
   L>   2.2.2.2/32         1        1         -          Yes   LSP_DEFAULT  3
xe1        No    10.10.10.2
                                   13        -          No    LSP_DEFAULT  25608
xe3       No    30.30.30.2
   L>   3.3.3.3/32         5        3         -          Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
                                   4         -          No    LSP_DEFAULT  25608
xe1        No    10.10.10.2
   L>   4.4.4.4/32         3        7         -          Yes   LSP_DEFAULT  25609
xe2       No    20.20.20.2
                                   8         -          No    LSP_DEFAULT  25609
xe1        No    10.10.10.2
   L>   5.5.5.5/32         7        5         -          Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
                                   9         -          No    LSP_DEFAULT  25600
xe1        No    10.10.10.2
   L>   40.40.40.0/24      2        1         -          Yes   LSP_DEFAULT  3
xe1        No    10.10.10.2
                                   14        -          No    LSP_DEFAULT  25611
xe3       No    30.30.30.2
   L>   50.50.50.0/24      6        3         -          Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
                                   11        -          No    LSP_DEFAULT  25611
xe1        No    10.10.10.2
   L>   60.60.60.0/24      4        6         -          Yes   LSP_DEFAULT  25613
xe2       No    20.20.20.2
                                   12        -          No    LSP_DEFAULT  25612
xe1        No    10.10.10.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        5         -          Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
                                   9         -          No    LSP_DEFAULT  25600
xe1        No    10.10.10.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
      Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
       Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

      Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 13
```

```
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608
    Nexthop addr: 30.30.30.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
    Nexthop addr: 10.10.10.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 5, in intf: - in label: 0  out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push
```

```
 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 2, in intf: - in label: 0  out-segment ix: 14
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25611
    Nexthop addr: 30.30.30.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 11, in intf: - in label: 0  out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611
    Nexthop addr: 10.10.10.2        cross connect ix: 11, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613
    Nexthop addr: 20.20.20.2        cross connect ix: 6, op code: Push

     Backup Cross connect ix: 13, in intf: - in label: 0  out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
    Nexthop addr: 10.10.10.2        cross connect ix: 13, op code: Push
```

```
PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label    ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610        No    no nexthop
                    NLP>    3.3.3.3             25610        No    20.20.20.2
                    NLB>    2.2.2.2             25600        No    10.10.10.2

PE1#show ip route fast-reroute
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p -
stale info, E - EVPN
       * - candidate default

IP Route Table for VRF "default"
i L1    2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 00:59:29
                   [FRR-NH] via 30.30.30.2, xe3

i L1    3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 00:57:59
                   [FRR-NH] via 10.10.10.2, xe1

i L1    4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 00:56:19
                   [FRR-NH] via 10.10.10.2, xe1

i L1    5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 00:57:09
                   [FRR-NH] via 10.10.10.2, xe1
```

```
i L1    40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 00:57:09
                      [FRR-NH] via 30.30.30.2, xe3

i L1    50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 00:57:09
                      [FRR-NH] via 10.10.10.2, xe1

i L1    60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 00:57:09
                      [FRR-NH] via 10.10.10.2, xe1

PE1#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

L1  2.2.2.2/32
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 30.30.30.2, xe3
    FRR Metric          : 90
    Protection Provided : LP BP

L1  3.3.3.3/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP BP

L1  4.4.4.4/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 50
    Protection Provided : LP NP BP DP

L1  5.5.5.5/32
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  40.40.40.0/24
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 30.30.30.2, xe3
    FRR Metric          : 80
    Protection Provided : LP NP BP DP

L1  50.50.50.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
```

```
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

L1  60.60.60.0/24
    Primary Path via    : 20.20.20.2, xe2
    FRR Backup Path via : 10.10.10.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP DP

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0        -                -                 kernel
1.1.1.1/32         0.0.0.0          lo         -                -                connected
2.2.2.2/32          10.10.10.2       xe1        30.30.30.2       xe3              isis
3.3.3.3/32          20.20.20.2       xe2       10.10.10.2       xe1              isis
4.4.4.4/32          20.20.20.2       xe2       10.10.10.2       xe1              isis
5.5.5.5/32          20.20.20.2       xe2       10.10.10.2       xe1              isis
10.10.10.0/24       0.0.0.0          xe1       -                -                connected
10.12.49.0/24       0.0.0.0          xe0       -                -                connected
20.20.20.0/24       0.0.0.0          xe2      -                -                 connected
30.30.30.0/24       0.0.0.0          xe3      -                -                 connected
40.40.40.0/24       10.10.10.2       xe1        30.30.30.2       xe3              isis
50.50.50.0/24       20.20.20.2       xe2       10.10.10.2       xe1              isis
60.60.60.0/24       20.20.20.2       xe2       10.10.10.2       xe1              isis


PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -           Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
                                    13        -           No    LSP_DEFAULT  25608
xe3        No    30.30.30.2
   L>   3.3.3.3/32         5         3         -           Yes   LSP_DEFAULT  3
xe2        No    20.20.20.2
                                    4         -           No    LSP_DEFAULT  25608
xe1         No    10.10.10.2
   L>   4.4.4.4/32         3         7         -           Yes   LSP_DEFAULT  25609
xe2        No    20.20.20.2
                                    8         -           No    LSP_DEFAULT  25609
xe1         No    10.10.10.2
   L>   5.5.5.5/32         7         5         -           Yes   LSP_DEFAULT  25610
xe2        No    20.20.20.2
                                    9         -           No    LSP_DEFAULT  25600
xe1         No    10.10.10.2
   L>   40.40.40.0/24      2         1         -           Yes   LSP_DEFAULT  3
xe1         No    10.10.10.2
```

```
                                14        -          No    LSP_DEFAULT  25611
xe3       No    30.30.30.2
   L>   50.50.50.0/24      6        3        -          Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
                                11        -          No    LSP_DEFAULT  25611
xe1        No    10.10.10.2
   L>   60.60.60.0/24      4        6        -          Yes   LSP_DEFAULT  25613
xe2       No    20.20.20.2
                                12        -          No    LSP_DEFAULT  25612
xe1        No    10.10.10.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        5        -          Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
                                9         -          No    LSP_DEFAULT  25600
xe1        No    10.10.10.2

PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 13
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608
    Nexthop addr: 30.30.30.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
        Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
    Nexthop addr: 10.10.10.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none

...skipping 1 line
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
      Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push

      Backup Cross connect ix: 5, in intf: - in label: 0  out-segment ix: 8
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
      Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

      Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
      Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
--More--
Most commands optionally preceded by integer argument k.  Defaults in brackets.
Star (*) indicates argument becomes new default.
-------------------------------------------------------------------------------
<space>                 Display next k lines of text [current screen size]
z                       Display next k lines of text [current screen size]*
<return>                Display next k lines of text [1]*
```

```
d or ctrl-D              Scroll k lines [current scroll size, initially 11]*
q or Q or <interrupt>    Exit from more
s                        Skip forward k lines of text [1]
f                        Skip forward k screenfuls of text [1]
b or ctrl-B              Skip backwards k screenfuls of text [1]
'                        Go to place where previous search started
=                        Display current line number
/<regular expression>    Search for kth occurrence of regular expression [1]
n                        Search for kth occurrence of last r.e [1]
!<cmd> or :!<cmd>        Execute <cmd> in a subshell
v                        Start up /usr/bin/vi at current line
ctrl-L                   Redraw screen
:n                       Go to kth next file [1]
:p                       Go to kth previous file [1]
:f                       Display current file name and line number
.                        Repeat previous command
-------------------------------------------------------------------------------
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 2, in intf: - in label: 0  out-segment ix: 14
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25611
    Nexthop addr: 30.30.30.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 11, in intf: - in label: 0  out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611
    Nexthop addr: 10.10.10.2        cross connect ix: 11, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
```

```
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613

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     Backup Cross connect ix: 13, in intf: - in label: 0  out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
    Nexthop addr: 10.10.10.2        cross connect ix: 13, op code: Push




PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NLP>    3.3.3.3             25610       No    20.20.20.2
                    NLB>    2.2.2.2             25600       No    10.10.10.2

PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push
```

```
     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 13
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe3, out label: 25608
    Nexthop addr: 30.30.30.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 4
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25608
    Nexthop addr: 10.10.10.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 5, in intf: - in label: 0  out-segment ix: 8
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25609
    Nexthop addr: 10.10.10.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
      Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
    Nexthop addr: 10.10.10.2        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 2, in intf: - in label: 0  out-segment ix: 14
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 14, owner: LDP, Stale: NO, out intf: xe3, out label: 25611
    Nexthop addr: 30.30.30.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push

     Backup Cross connect ix: 11, in intf: - in label: 0  out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 25611
    Nexthop addr: 10.10.10.2        cross connect ix: 11, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613
    Nexthop addr: 20.20.20.2        cross connect ix: 6, op code: Push

     Backup Cross connect ix: 13, in intf: - in label: 0  out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe1, out label: 25612
```

```
    Nexthop addr: 10.10.10.2        cross connect ix: 13, op code: Push


PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session            Out Label    ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4            25610        No    no nexthop
                    NLP>    3.3.3.3            25610        No    20.20.20.2
                    NLB>    2.2.2.2            25600        No    10.10.10.2
```

Backup Path based on Route-Map Prefixes

`(config)#ip access-list A`	Create an access-list
`(config-ip-acl)#10 permit any host 40.40.40.0 any`	Configuring rule to permit only one prefix
`(config)#route-map R permit 10`	Create a route-map
`(config-route-map)#match ip address A`	Apply above created access-list in route-map
`(config-route-map)#exit`	Exit route-map mode
`(config)#commit`	Commit all the configurations

Apply the above created route-map with fast-reroute:

`(config)#router isis 1`	Create an IS-IS routing instance for area 49 with instance 1
`(config-router)#no fast-reroute per-prefix level-1 proto ipv4`	Un-configure LFA-FRR to calculate available path for all prefixes
`(config-router)#fast-reroute per-prefix level-1 proto ipv4 route-map R`	Configure LFA-FRR to calculate the available backup path for routes allowed through route-map
`(config-router)#exit`	Exit router mode
`(config)#commit`	Commit all the configurations

Validation

```
PE1#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State   Holdtime   Type Protocol
P1             xe1         5254.0002.5b0a      Up      28         L1   IS-IS
P2             xe2        5254.009b.f9a2      Up      7          L1   IS-IS
```

```
P3              xe3       5254.005d.e995      Up     5         L1   IS-IS

PE1#show clns neighbors detail

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 0
Total number of adjacencies: 3
Tag 1:  VRF : default
System Id      Interface   SNPA                State  Holdtime  Type Protocol
P1              xe1        5254.0002.5b0a      Up     26        L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 01:04:52
  Area Address(es): 49.0001
  IP Address(es): 10.10.10.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P2              xe2       5254.009b.f9a2      Up     8         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 01:04:28
  Area Address(es): 49.0001
  IP Address(es): 20.20.20.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
P3              xe3       5254.005d.e995      Up     7         L1   IS-IS
  L1  Adjacency ID: 1
  L2  Adjacency ID: 2
  Uptime: 01:04:03
  Area Address(es): 49.0001
  IP Address(es): 30.30.30.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise

PE1#show isis database
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00           * 0x0000000E   0xD3A3        968               0/0/0
PE1.02-00           * 0x00000005   0x8047        908               0/0/0
P1.00-00              0x0000000C   0xBA5B        1035              0/0/0
P1.03-00              0x00000005   0xB60B        995               0/0/0
P2.00-00              0x0000000B   0xFA56        1039              0/0/0
P2.02-00              0x00000005   0x6E56        931               0/0/0
P2.03-00              0x00000005   0xB708        1025              0/0/0
P3.00-00              0x0000000B   0xD9B2        1060              0/0/0
P3.02-00              0x00000005   0x6F53        946               0/0/0
```

```
PE2.00-00            0x0000000E   0xDB03       1056              0/0/0
PE2.04-00            0x00000005   0x9E1D       1055              0/0/0

PE1#show isis database verbose
Tag 1:  VRF : default
IS-IS Level-1 Link State Database:
LSPID                LSP Seq Num  LSP Checksum  LSP Holdtime      ATT/P/OL
PE1.00-00          * 0x0000000E   0xD3A3       963               0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE1
  IP Address:   1.1.1.1
  Router ID:    10.12.49.172
  Metric:   20         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.1
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 20
  Metric:   15         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.1
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 15
  Metric:   60         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.1
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
```

```
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 60
  Metric:   10         IP-Extended 1.1.1.1/32
  Metric:   20         IP-Extended 10.10.10.0/24
  Metric:   15         IP-Extended 20.20.20.0/24
  Metric:   60         IP-Extended 30.30.30.0/24
PE1.02-00           * 0x00000005   0x8047        902              0/0/0
  Metric:   0          IS-Extended PE1.00
  Metric:   0          IS-Extended P1.00
P1.00-00              0x0000000C   0xBA5B        1030             0/0/0
  Area Address: 49.0001
  NLPID:         0xCC
  Hostname:      P1
  IP Address:    2.2.2.2
  Router ID:     10.12.49.173
  Metric:   10         IS-Extended PE1.02
    IPv4 Interface Address: 10.10.10.2
    Neighbor IP Address: 10.10.10.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.1
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
```

```
    TE-Default Metric: 10
  Metric:   10         IP-Extended 2.2.2.2/32
  Metric:   10         IP-Extended 10.10.10.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
P1.03-00              0x00000005   0xB60B        990               0/0/0
  Metric:   0          IS-Extended P1.00
  Metric:   0          IS-Extended PE2.00
P2.00-00              0x0000000B   0xFA56        1034              0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P2
  IP Address:   3.3.3.3
  Router ID:    10.12.49.176
  Metric:   10         IS-Extended P2.02
    IPv4 Interface Address: 20.20.20.2
    Neighbor IP Address: 20.20.20.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.1
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 3.3.3.3/32
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 20.20.20.0/24
P2.02-00              0x00000005   0x6E56        926               0/0/0
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE1.00
P2.03-00              0x00000005   0xB708        1020              0/0/0
```

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```
  Metric:   0          IS-Extended P2.00
  Metric:   0          IS-Extended PE2.00
P3.00-00              0x0000000B   0xD9B2        1055              0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     P3
  IP Address:   4.4.4.4
  Router ID:    10.12.49.177
  Metric:   10         IS-Extended P3.02
    IPv4 Interface Address: 30.30.30.2
    Neighbor IP Address: 30.30.30.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.1
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 4.4.4.4/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 30.30.30.0/24
P3.02-00              0x00000005   0x6F53        941               0/0/0
  Metric:   0          IS-Extended P3.00
  Metric:   0          IS-Extended PE1.00
PE2.00-00             0x0000000E   0xDB03        1051              0/0/0
  Area Address: 49.0001
  NLPID:        0xCC
  Hostname:     PE2
  IP Address:   5.5.5.5
  Router ID:    10.12.49.174
```

```
  Metric:   10         IS-Extended P1.03
    IPv4 Interface Address: 40.40.40.2
    Neighbor IP Address: 40.40.40.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended P2.03
    IPv4 Interface Address: 50.50.50.2
    Neighbor IP Address: 50.50.50.1
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IS-Extended PE2.04
    IPv4 Interface Address: 60.60.60.2
    Neighbor IP Address: 60.60.60.2
    Maximum Link Bandwidth : 100000.00 kbits/sec
    Reservable Bandwidth : 100000.00 kbits/sec
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 1: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 2: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 3: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 4: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 5: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 6: 100000.00 kbits/sec
      Unreserved Bandwidth at priority 7: 100000.00 kbits/sec
    TE-Default Metric: 10
  Metric:   10         IP-Extended 5.5.5.5/32
  Metric:   10         IP-Extended 60.60.60.0/24
  Metric:   10         IP-Extended 50.50.50.0/24
  Metric:   10         IP-Extended 40.40.40.0/24
PE2.04-00             0x00000005   0x9E1D       1050              0/0/0
```

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```
  Metric:   0          IS-Extended PE2.00
  Metric:   0          IS-Extended P3.00


PE1#show ldp session
Peer IP Address          IF Name    My Role    State      KeepAlive  UpTime
5.5.5.5                  xe3      Passive   OPERATIONAL   30    01:02:53
2.2.2.2                  xe1       Passive   OPERATIONAL   30    01:04:55
3.3.3.3                  xe2      Passive   OPERATIONAL   30    01:04:07
4.4.4.4                  xe3      Passive   OPERATIONAL   30    01:04:14
PE1#show ldp routes
Prefix Addr          Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0            10.12.49.1       xe0        -                -                kernel
1.1.1.1/32          0.0.0.0          lo         -               -               connected
2.2.2.2/32           10.10.10.2       xe1        -                -                isis
3.3.3.3/32           20.20.20.2       xe2       -                -                isis
4.4.4.4/32           20.20.20.2       xe2       -                -                isis
5.5.5.5/32           20.20.20.2       xe2       -                -                isis
10.10.10.0/24       0.0.0.0          xe1       -               -               connected
10.12.49.0/24       0.0.0.0          xe0       -               -               connected
20.20.20.0/24       0.0.0.0          xe2      -               -               connected
30.30.30.0/24       0.0.0.0          xe3      -               -               connected
40.40.40.0/24        10.10.10.2       xe1        30.30.30.2       xe3           isis
50.50.50.0/24        20.20.20.2       xe2       -                -                isis
60.60.60.0/24        20.20.20.2       xe2       -                -                isis

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0

K*            0.0.0.0/0 [0/0] via 10.12.49.1, xe0
C             1.1.1.1/32 is directly connected, lo, 01:13:04
i L1          2.2.2.2/32 [115/30] via 10.10.10.2, xe1, 01:05:05
i L1          3.3.3.3/32 [115/25] via 20.20.20.2, xe2, 01:03:35
i L1          4.4.4.4/32 [115/45] via 20.20.20.2, xe2, 01:01:55
i L1          5.5.5.5/32 [115/35] via 20.20.20.2, xe2, 01:02:45
C             10.10.10.0/24 is directly connected, xe1, 01:13:04
C             10.12.49.0/24 is directly connected, xe0, 01:17:43
C             20.20.20.0/24 is directly connected, xe2, 01:13:04
C             30.30.30.0/24 is directly connected, xe3, 01:13:04
i L1          40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 01:02:45
```

```
i L1         50.50.50.0/24 [115/25] via 20.20.20.2, xe2, 01:02:45
i L1         60.60.60.0/24 [115/35] via 20.20.20.2, xe2, 01:02:45
C            127.0.0.0/8 is directly connected, lo, 03:48:54

PE1#show ip route summary

-----------------------------------------------
IP routing table name is Default-IP-Routing-Table(0)
-----------------------------------------------
IP routing table maximum-paths   : 8
Total number of IPv4 routes      : 14
Total number of IPv4 paths       : 14
Pending routes (due to route max reached): 0
Route Source    Networks
kernel          1
connected       6
isis            7
Total           14
FIB             14

ECMP statistics (active in ASIC):
 Total number of IPv4 ECMP routes : 0
 Total number of IPv4 ECMP paths  : 0

 LFA Non ECMP statistics
 --------------
 Total number of Routes        : 1
 Total number of Primary Paths : 1
 Total number of Backup Paths  : 1

PE1#show ip interface brief

'*' - address is assigned by dhcp client

Interface            IP-Address      Admin-Status          Link-Status
xe0                 *10.12.49.172    up                    up
xe1                  unassigned      up                    up
xe1                  10.10.10.1      up                    up
xe3                  unassigned      up                    up
xe4                  unassigned      up                    up
xe5                  unassigned      up                    up
xe6                  unassigned      up                    up
xe7                  unassigned      up                    up
xe8                  unassigned      up                    up
xe9                  unassigned      up                    up
xe10                 unassigned      up                    up
xe11                 unassigned      up                    up
xe2                 20.20.20.1      up                    up
xe3                 30.30.30.1      up                    up
lo                    127.0.0.1       up                    up
```

```
PE1#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

L1  40.40.40.0/24
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 30.30.30.2, xe3
    FRR Metric          : 80
    Protection Provided : LP NP BP DP

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0        -                -                 kernel
1.1.1.1/32          0.0.0.0         lo         -               -                connected
2.2.2.2/32           10.10.10.2       xe1        -                -                 isis
3.3.3.3/32           20.20.20.2       xe2       -                -                 isis
4.4.4.4/32           20.20.20.2       xe2       -                -                 isis
5.5.5.5/32           20.20.20.2       xe2       -                -                 isis
10.10.10.0/24       0.0.0.0         xe1       -               -                connected
10.12.49.0/24       0.0.0.0         xe0       -               -                connected
20.20.20.0/24       0.0.0.0         xe2      -               -                connected
30.30.30.0/24       0.0.0.0         xe3      -               -                connected
40.40.40.0/24        10.10.10.2       xe1        30.30.30.2       xe3             isis
50.50.50.0/24        20.20.20.2       xe2       -                -                 isis
60.60.60.0/24        20.20.20.2       xe2       -                -                 isis

PE1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          E >     non-existent        none        No    connected
2.2.2.2/32          NL      4.4.4.4             25608       No    no nexthop
                    NL      3.3.3.3             25608       No    no nexthop
                    NLP>    2.2.2.2             impl-null   No    10.10.10.2
3.3.3.3/32          NL      2.2.2.2             25608       No    no nexthop
                    NL      4.4.4.4             25609       No    no nexthop
                    NLP>    3.3.3.3             impl-null   No    20.20.20.2
4.4.4.4/32          NL      2.2.2.2             25609       No    no nexthop
                    NLP>    3.3.3.3             25609       No    20.20.20.2
                    NL      4.4.4.4             impl-null   No    no nexthop
5.5.5.5/32          NL      4.4.4.4             25610       No    no nexthop
                    NLP>    3.3.3.3             25610       No    20.20.20.2
```

```
                    NL      2.2.2.2             25600       No    no nexthop
10.10.10.0/24       NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
10.12.49.0/24       NL      3.3.3.3             impl-null   No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL      3.3.3.3             impl-null   No    connected
                    E >     non-existent        none        No    connected
30.30.30.0/24       NL      2.2.2.2             25610       No    connected
                    NL      3.3.3.3             25611       No    connected
                    NL      4.4.4.4             impl-null   No    connected
                    E >     non-existent        none        No    connected
40.40.40.0/24       NLB>    4.4.4.4             25611       No    30.30.30.2
                    NL      3.3.3.3             25612       No    no nexthop
                    NLP>    2.2.2.2             impl-null   No    10.10.10.2
50.50.50.0/24       NL      2.2.2.2             25611       No    no nexthop
                    NL      4.4.4.4             25612       No    no nexthop
                    NLP>    3.3.3.3             impl-null   No    20.20.20.2
60.60.60.0/24       NL      2.2.2.2             25612       No    no nexthop
                    NLP>    3.3.3.3             25613       No    20.20.20.2
                    NL      4.4.4.4             impl-null   No    no nexthop
PE1#show ldp downstream
Codes: P - Primary route, B - Backup route
Session peer 5.5.5.5:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
Codes: P - Primary route, B - Backup route
Session peer 2.2.2.2:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
  60.60.60.0/24       connected        Established      25612       0
  50.50.50.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      25610       0
  4.4.4.4/32          connected        Established      25609       0
  3.3.3.3/32          connected        Established      25608       0
  5.5.5.5/32          connected        Established      25600       0
  40.40.40.0/24      10.10.10.2     Established     impl-null   0
P
  10.12.49.0/24       connected        Established      impl-null   0
  10.10.10.0/24       connected        Established      impl-null   0
  2.2.2.2/32         10.10.10.2     Established     impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 3.3.3.3:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
  40.40.40.0/24       connected        Established      25612       0
  30.30.30.0/24       connected        Established      25611       0
  4.4.4.4/32         20.20.20.2     Established     25609      0
P
  2.2.2.2/32          connected        Established      25608       0
```

```
  60.60.60.0/24      20.20.20.2      Established     25613      0
P
  5.5.5.5/32        20.20.20.2      Established     25610      0
P
  50.50.50.0/24      20.20.20.2      Established     impl-null   0
P
   20.20.20.0/24       connected        Established      impl-null   0
   10.12.49.0/24       connected        Established      impl-null   0
  3.3.3.3/32        20.20.20.2      Established     impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 4.4.4.4:
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
   50.50.50.0/24       connected        Established      25612       0
   40.40.40.0/24       connected        Established      25611       0
  40.40.40.0/24      30.30.30.2      Established     25611      0
B
   5.5.5.5/32          connected        Established      25610       0
   3.3.3.3/32          connected        Established      25609       0
   2.2.2.2/32          connected        Established      25608       0
   60.60.60.0/24       connected        Established      impl-null   0
   30.30.30.0/24       connected        Established      impl-null   0
   10.12.49.0/24       connected        Established      impl-null   0
   4.4.4.4/32          connected        Established      impl-null   0

PE1#show ldp lsp
DOWNSTREAM LSP :
  FEC              Nexthop Addr    State          Label      Req.ID     Attr
Code
   1.1.1.1/32          connected        Established      none        0           None
   2.2.2.2/32          connected        Established      25608       0
   2.2.2.2/32          connected        Established      25608       0
  2.2.2.2/32        10.10.10.2      Established     impl-null   0
P
   3.3.3.3/32          connected        Established      25608       0
   3.3.3.3/32          connected        Established      25609       0
  3.3.3.3/32        20.20.20.2      Established     impl-null   0
P
   4.4.4.4/32          connected        Established      25609       0
  4.4.4.4/32        20.20.20.2      Established     25609      0
P
   4.4.4.4/32          connected        Established      impl-null   0
   5.5.5.5/32          connected        Established      25610       0
  5.5.5.5/32        20.20.20.2      Established     25610      0
P
   5.5.5.5/32          connected        Established      25600       0
   10.10.10.0/24       connected        Established      impl-null   0
   10.10.10.0/24       connected        Established      none        0           None
   10.12.49.0/24       connected        Established      impl-null   0
   10.12.49.0/24       connected        Established      impl-null   0
   10.12.49.0/24       connected        Established      impl-null   0
   10.12.49.0/24       connected        Established      none        0           None
```

```
  20.20.20.0/24       connected        Established      impl-null   0
  20.20.20.0/24       connected        Established      none        0           None
  30.30.30.0/24       connected        Established      25610       0
  30.30.30.0/24       connected        Established      25611       0
  30.30.30.0/24       connected        Established      impl-null   0
  30.30.30.0/24       connected        Established      none        0           None
  40.40.40.0/24       connected        Established      25611       0
 40.40.40.0/24      30.30.30.2      Established     25611      0
B
  40.40.40.0/24       connected        Established      25612       0
 40.40.40.0/24      10.10.10.2      Established     impl-null   0
P
  50.50.50.0/24       connected        Established      25611       0
  50.50.50.0/24       connected        Established      25612       0
 50.50.50.0/24      20.20.20.2      Established     impl-null   0
P
  60.60.60.0/24       connected        Established      25612       0
 60.60.60.0/24      20.20.20.2      Established     25613      0
P
  60.60.60.0/24       connected        Established      impl-null   0

UPSTREAM LSP :
  FEC                 State            Label        Req.ID      Attr
  1.1.1.1/32          Established      impl-null    0           None
  1.1.1.1/32          Established      impl-null    0           None
  1.1.1.1/32          Established      impl-null    0           None
  2.2.2.2/32          Established      25608        0           None
  2.2.2.2/32          Established      25604        0           None
  2.2.2.2/32          Established      25604        0           None
  2.2.2.2/32          Established      25608        0           None
  3.3.3.3/32          Established      25605        0           None
  3.3.3.3/32          Established      25600        0           None
  3.3.3.3/32          Established      25605        0           None
  3.3.3.3/32          Established      25600        0           None
  4.4.4.4/32          Established      25603        0           None
  4.4.4.4/32          Established      25602        0           None
  4.4.4.4/32          Established      25603        0           None
  4.4.4.4/32          Established      25602        0           None
  5.5.5.5/32          Established      25614        0           None
  5.5.5.5/32          Established      25614        0           None
  5.5.5.5/32          Established      25615        0           None
  5.5.5.5/32          Established      25615        0           None
  10.10.10.0/24       Established      impl-null    0           None
  10.10.10.0/24       Established      impl-null    0           None
  10.10.10.0/24       Established      impl-null    0           None
  10.12.49.0/24       Established      impl-null    0           None
  10.12.49.0/24       Established      impl-null    0           None
  10.12.49.0/24       Established      impl-null    0           None
  20.20.20.0/24       Established      impl-null    0           None
  20.20.20.0/24       Established      impl-null    0           None
  20.20.20.0/24       Established      impl-null    0           None
```

```
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  30.30.30.0/24       Established      impl-null   0           None
  40.40.40.0/24       Established      25610       0           None
  40.40.40.0/24       Established      25606       0           None
  40.40.40.0/24       Established      25606       0           None
  40.40.40.0/24       Established      25610       0           None
  50.50.50.0/24       Established      25607       0           None
  50.50.50.0/24       Established      25601       0           None
  50.50.50.0/24       Established      25607       0           None
  50.50.50.0/24       Established      25601       0           None
  60.60.60.0/24       Established      25616       0           None
  60.60.60.0/24       Established      25616       0           None
  60.60.60.0/24       Established      25617       0           None
  60.60.60.0/24       Established      25617       0           None

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1        1         -          Yes   LSP_DEFAULT  3
xe1        No    10.10.10.2
   L>   3.3.3.3/32         5        3         -          Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
   L>   4.4.4.4/32         3        7         -          Yes   LSP_DEFAULT  25609
xe2       No    20.20.20.2
   L>   5.5.5.5/32         7        5         -          Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
   L>   40.40.40.0/24      2        1         -          Yes   LSP_DEFAULT  3
xe1        No    10.10.10.2
                                   15        -          No    LSP_DEFAULT  25611
xe3       No    30.30.30.2
   L>   50.50.50.0/24      6        3         -          Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
   L>   60.60.60.0/24      4        6         -          Yes   LSP_DEFAULT  25613
xe2       No    20.20.20.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        5         -          Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
```

```
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
```

```
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 15
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 15, owner: LDP, Stale: NO, out intf: xe3, out label: 25611
    Nexthop addr: 30.30.30.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613
    Nexthop addr: 20.20.20.2        cross connect ix: 6, op code: Push


PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
```

```
5.5.5.5/32          NL      4.4.4.4            25610       No    no nexthop
                    NLP>    3.3.3.3            25610       No    20.20.20.2
                    NL      2.2.2.2            25600       No    no nexthop
PE1#show ip route fast-reroute
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area ,p -
stale info, E - EVPN
       * - candidate default

IP Route Table for VRF "default"
i L1    40.40.40.0/24 [115/30] via 10.10.10.2, xe1, 01:04:31
                      [FRR-NH] via 30.30.30.2, xe3

PE1#show ip isis route fast-reroute

Tag   : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

L1  40.40.40.0/24
    Primary Path via    : 10.10.10.2, xe1
    FRR Backup Path via : 30.30.30.2, xe3
    FRR Metric          : 80
    Protection Provided : LP NP BP DP

PE1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf      Owner
0.0.0.0/0           10.12.49.1       xe0        -                -                 kernel
1.1.1.1/32          0.0.0.0         lo         -                -                connected
2.2.2.2/32          10.10.10.2       xe1        -                -                 isis
3.3.3.3/32          20.20.20.2       xe2       -                -                 isis
4.4.4.4/32          20.20.20.2       xe2       -                -                 isis
5.5.5.5/32          20.20.20.2       xe2       -                -                 isis
10.10.10.0/24       0.0.0.0         xe1       -                -                connected
10.12.49.0/24       0.0.0.0         xe0       -                -                connected
20.20.20.0/24       0.0.0.0         xe2      -                -                connected
30.30.30.0/24       0.0.0.0         xe3      -                -                connected
40.40.40.0/24       10.10.10.2       xe1       30.30.30.2       xe3             isis
50.50.50.0/24       20.20.20.2       xe2       -                -                 isis
60.60.60.0/24       20.20.20.2       xe2       -                -                 isis

PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
```

```
Code    FEC                FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1        1         -           Yes   LSP_DEFAULT  3
xe1        No    10.10.10.2
   L>   3.3.3.3/32         5        3         -           Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
   L>   4.4.4.4/32         3        7         -           Yes   LSP_DEFAULT  25609
xe2       No    20.20.20.2
   L>   5.5.5.5/32         7        5         -           Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
   L>   40.40.40.0/24      2        1         -           Yes   LSP_DEFAULT  3
xe1        No    10.10.10.2
                                    15        -           No    LSP_DEFAULT  25611
xe3       No    30.30.30.2
   L>   50.50.50.0/24      6        3         -           Yes   LSP_DEFAULT  3
xe2       No    20.20.20.2
   L>   60.60.60.0/24      4        6         -           Yes   LSP_DEFAULT  25613
xe2       No    20.20.20.2

PE1#show mpls forwarding-table 5.5.5.5/32
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   5.5.5.5/32         7        5         -           Yes   LSP_DEFAULT  25610
xe2       No    20.20.20.2
PE1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push
```

```
 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:368, pkts:4, TX bytes:368, Pushed pkts:4
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25609
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 40.40.40.0/24, id: 2, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.10.10.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 15
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 15, owner: LDP, Stale: NO, out intf: xe3, out label: 25611
    Nexthop addr: 30.30.30.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 50.50.50.0/24, id: 6, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 4, op code: Push
```

```
 Primary FTN entry with FEC: 60.60.60.0/24, id: 4, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25613
    Nexthop addr: 20.20.20.2        cross connect ix: 6, op code: Push

PE1#show mpls ftn-table 5.5.5.5/32
 Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Matched bytes:339, pkts:4, TX bytes:355, Pushed pkts:4
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25610
    Nexthop addr: 20.20.20.2        cross connect ix: 5, op code: Push


PE1#show ldp fec prefix 5.5.5.5/32
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               P - Primary route, B - LFA Backup route,
               R - Remote LFA Backup route,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label    ELC   Nexthop Addr
5.5.5.5/32          NL      4.4.4.4             25610        No    no nexthop
                    NLP>    3.3.3.3             25610        No    20.20.20.2
                    NL      2.2.2.2             25600        No
```

CHAPTER 5 TCP MSS configuration for LDP sessions

Overview

Label Distribution Protocol (LDP) uses Transmission Control Protocol (TCP) to establish sessions between the devices. This feature enables the configuration of TCP Maximum Segment Size (MSS) that defines the maximum segment size in a single TCP segment during a communication session.TCP segment is a unit of data transmitted in a TCP connection. TCP uses three-way handshake process for initial establishment of a TCP connection. In the three-way handshake process, the sending host sends a SYN packet. Once the receiving host receives the SYN packet, it acknowledges and sends back a SYN-ACK packet to the sending host. Once the sending host receives the SYN-ACK packet from the receiving host, it sends an ACK packet, establishing a reliable connection. In this three way handshake process, the MSS is negotiated between the LDP neighbors.

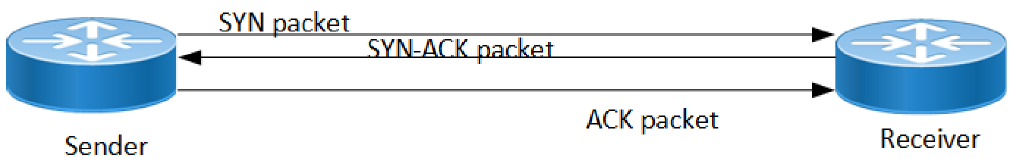

Figure 5-4: Three-way handshake

Feature Characteristics

The configuration of the TCP MSS for LDP neighbors helps the neighbors adjust the MSS value of the TCP SYN packet. Configure the TCP MSS through the CLI and NetConf interface. The configurable MSS range is offered from 560 to 1440. By default, the MTU value for ethernet cable is 1500 bytes. When configuring the highest MSS value that is 1440, the total MSS becomes 1440 bytes (MSS) plus 20 bytes (IP Header Size), 20 bytes (TCP Header), and Ethernet header which does not cross the default path MTU value.

Note: After configuring TCP MSS, use clear ldp session command to apply the MSS for the operational session.

Configuring TCP MSS

Benefits

By default, the interface MTU value determines the MSS value of an LDP packet. When the interface MTU value exceeds the default ethernet path MTU value of 1500 bytes, the MSS value also crosses the default ethernet path MTU value, resulting in packet fragmentation. The configuration of the specific MSS value limits the packet size irrespective of the interface MTU value, preventing packet fragmentation.[

Prerequisites

Requires the knowledge on TCP handshake and the formation of LDP neighbors.

Configuration

This section shows the procedure to configure TCP MSS for LDP session.

Enable Label Switching

Running LDP on a system requires the following tasks:

1. Enabling label-switching on the interface on NSM.
2. Enabling LDP on an interface in the LDP daemon.
3. Running an Internal Gateway Protocol (IGP), for example, Open Shortest Path first (OSPF), to distribute reachability information within the MPLS cloud.
4. Configuring the transport address.
5. Configure the TCP MSS neighbor on peer node (Active node).

Topology

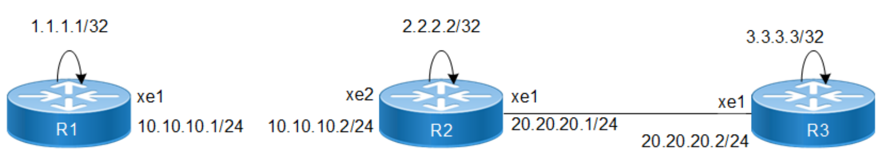

Figure 5-5: Device topology for TCP MSS for LDP

Configuration

The below configuration shows how to configure the TCP MSS value for the LDP neighbors.

R1 - NSM

`R1#configure terminal`	Enter configure mode.
`R1(config)#interface xe1`	Specify the interface `xe1` to be configured.
`R1(config-if)#ip address 10.10.10.1/24`	Assign IP address `10.10.10.1/24` to interface.
`R1(config-if)#label-switching`	Enable label switching on interface `xe1`.
`R1(config-if)#exit`	Exit interface mode.

`R1(config)#interface lo`	Specify the loopback interface to be configured.
`R1(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address of the loopback interface to `1.1.1.1/32`.
`R1(config-if)#commit`	Commit the transaction.

R1 - LDP

`R1(config)#router ldp`	Enter Router mode for LDP.
`R1(config-router)#router-id 1.1.1.1`	Set the router ID to IP address `1.1.1.1`.
`R1(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter `ipv6` if you are configuring an IPv6 interface.
`R1(config-router)#targeted-peer ipv4 3.3.3.3`	Configure targeted peer `3.3.3.3`.
`R1(config-router-targeted-peer)#exit`	Exit targeted peer-mode.
`R1(config-router)#exit`	Exit the router mode and return to the configure mode.
`R1(config)#interface xe1`	Enter interface mode `xe1`.
`R1(config-if)#enable-ldp ipv4`	Enable LDP on `xe1`.
`R1(config-if)#commit`	Commit the transaction.

R1 - OSPF

`R1(config)#router ospf 100`	Configure the routing process and specify the process ID `100`. The process ID should be a unique positive integer identifying the routing process.
`R1(config-router)#network 10.10.10.0/24 area 0`	Define the interface `10.10.10.0/24`,on which OSPF runs and associate the area ID `0` with the interface.
`R1(config-router)#network 1.1.1.1/32 area 0`	Define the interface `1.1.1.1/32`, on which OSPF runs and associate the area ID `0` with the interface.
`R1(config-router)#commit`	Commit the transaction.

R2 - NSM

`R2#configure terminal`	Enter configure mode.
`R2(config)#interface lo`	Specify the loopback interface to be configured.
`R2(config-if)#ip address 2.2.2.2/32 secondary`	Set the IP address of the loopback interface to `2.2.2.2/32`.
`R2(config-if)#exit`	Exit interface mode.
`R2(config)#interface xe1`	Specify the interface `xe1` to be configured.
`R2(config-if)#ip address 20.20.20.1/24`	Assign IP address `20.20.20.1/24` to interface.
`R2(config-if)#label-switching`	Enable label switching on interface `xe1`.
`R2(config-if)#exit`	Exit interface mode.
`R2(config)#interface xe2`	Specify the interface `xe2` to be configured.

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R2(config-if)#ip address 10.10.10.2/24	Assign IP address 10.10.10.2/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - LDP

R2(config)#router ldp	Enter Router mode.
R2(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
R2(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter ipv6 if you are configuring an IPv6 interface.
R2(config-router)#neighbor 1.1.1.1 tcp-mss 600	Configure the TCP MSS value on peer node which have active side only.
R2(config-router)#exit	Exit router mode and return to configure mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - OSPF

R2(config)#router ospf 100	Configure the routing process and specify the process ID 100. The process ID should be a unique positive integer identifying the routing process.
R2(config-router)#network 10.10.10.0/24 area 0	Define the interfaces 10.10.10.0/24, on which OSPF runs and associate the area ID 0 with them.
R2(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID 0 with them.
R2(config-router)#network 2.2.2.2/32 area 0	Define the interfaces 2.2.2.2/32, on which OSPF runs and associate the area ID 0 with them.
R2(config-router)#commit	Commit the transaction.

R3 - NSM

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Specify the loopback interface to be configured.
R3(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface xe1	Specify the interface xe1 to be configured.

`R3(config-if)#ip address 20.20.20.2/24`	Set the IP address of the interface to `20.20.20.2/24`.
`R3(config-if)#label-switching`	Enable label switching on interface `xe1`.
`R3(config-if)#commit`	Commit the transaction.

R3 - LDP

`R3(config)#router ldp`	Enter Router mode.
`R3(config-router)#router-id 3.3.3.3`	Set the router ID for IP address `3.3.3.3`.
`R3(config-router)#transport-address ipv4 3.3.3.3`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter `ipv6` if you are configuring an IPv6 interface.
`R3(config-router)#neighbor 2.2.2.2 tcp-mss 650`	Configure the TCP MSS value on peer node which have active side only.
`R3(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted peer.
`R3(config-router-targeted-peer)#exit`	Exit targeted peer-mode.
`R3(config-router)#exit`	Exit the router mode and return to the configure mode.
`R3(config)#interface xe1`	Enter interface mode `xe1`.
`R3(config-if)#enable-ldp ipv4`	Enable LDP on `xe1`.
`R3(config-if)#commit`	Commit the transaction.

R3 - OSPF

`R3(config)#router ospf 100`	Configure the routing process and specify the Process ID `100`. The Process ID should be a unique positive integer identifying the routing process.
`R3(config-router)#network 20.20.20.0/24 area 0`	Define the interfaces `20.20.20.0/24`, on which OSPF runs and associate the area ID `0` with them.
`R3(config-router)#network 3.3.3.3/32 area 0`	Define the interfaces `3.3.3.3/32`, on which OSPF runs and associate the area ID `0` with them.
`R3(config-router)#commit`	Commit the transaction.

Validation

R3

```
R3#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       2.2.2.2            xe1        Active    OPERATIONAL   30    00:03:06
```

```
       1.1.1.1            xe1        Active    OPERATIONAL   30    00:03:06
R3#show ldp targeted-peer count
-------------------------------------------------
Num Targeted Peers: 1          [UP: 1]
-------------------------------------------------
PE2#show ldp session count
--------------------------------------------
 Multicast Peers      : 1          [UP: 1]
 Targeted Peers       : 1          [UP: 1]
 Total Sessions       : 2          [UP: 2]
--------------------------------------------
R3#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Owner
1.1.1.1/32          20.20.20.1       xe1         ospf
2.2.2.2/32          20.20.20.1       xe1         ospf
3.3.3.3/32          0.0.0.0          lo          connected
10.10.10.0/24       20.20.20.1       xe1         ospf
20.20.20.0/24       0.0.0.0          xe1         connected
R3#show ldp fec-ipv4 count
------------------------
Num. IPv4 FEC(s): 5
------------------------
R3#show ldp session 2.2.2.2
Session state                 : OPERATIONAL
Session role                  : Active
TCP Connection                : Established
IP Address for TCP            : 2.2.2.2
Interface being used          : xe1
Peer LDP ID                   : 2.2.2.2:0
Preferred Peer LDP Password   : Not Set
Adjacencies                   : 20.20.20.1
Advertisement mode            : Downstream Unsolicited
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 650
Applied TCP MSS               : 650
Preferred TCP MSS             : NA
Address List received         : 2.2.2.2
                                10.10.10.2
                                20.20.20.1
Received Labels :       Fec             Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:2.2.2.2/32         impl-null       none
                IPV4:1.1.1.1/32         25600           none
Sent Labels :   Fec                     Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:3.3.3.3/32         impl-null       none
```

R2

```
R2#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually
Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       3.3.3.3            xe1        Passive   OPERATIONAL   30    00:06:10
       1.1.1.1            xe2       Active    OPERATIONAL   30    00:06:10
R2#show ldp session count
--------------------------------------------
 Multicast Peers      : 2          [UP: 2]
 Targeted Peers       : 0          [UP: 0]
 Total Sessions       : 2          [UP: 2]
--------------------------------------------
R2#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Owner
1.1.1.1/32          10.10.10.1       xe2        ospf
2.2.2.2/32          0.0.0.0          lo          connected
3.3.3.3/32          20.20.20.2       xe1         ospf
10.10.10.0/24       0.0.0.0          xe2        connected
20.20.20.0/24       0.0.0.0          xe1         connected

R2#show ldp session 1.1.1.1
Session state                 : OPERATIONAL
Session role                  : Active
TCP Connection                : Established
IP Address for TCP            : 1.1.1.1
Interface being used          : xe2
Peer LDP ID                   : 1.1.1.1:0
Preferred Peer LDP Password   : Not Set
Adjacencies                   : 10.10.10.1
Advertisement mode            : Downstream Unsolicited
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 600
Applied TCP MSS               : 600
Preferred TCP MSS             : NA
Address List received         : 1.1.1.1
                                10.10.10.1
                                48.48.48.48
Received Labels :       Fec               Label           Maps To
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:1.1.1.1/32         impl-null       25600
Sent Labels :   Fec                       Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
```

```
                IPV4:3.3.3.3/32        25601          impl-null
                IPV4:2.2.2.2/32        impl-null      none
```

R1

```
R1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       2.2.2.2            xe1        Passive   OPERATIONAL   30    00:07:12
       3.3.3.3            xe1        Passive   OPERATIONAL   30    00:07:12
R1#show ldp session count
--------------------------------------------
 Multicast Peers      : 1          [UP: 1]
 Targeted Peers       : 1          [UP: 1]
 Total Sessions       : 2          [UP: 2]
--------------------------------------------
R1#show ldp targeted-peer count
-------------------------------------------------
Num Targeted Peers: 1          [UP: 1]
-------------------------------------------------
R1#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Owner
1.1.1.1/32          0.0.0.0          lo          connected
2.2.2.2/32          10.10.10.2       xe1        ospf
3.3.3.3/32          10.10.10.2       xe1         ospf
10.10.10.0/24       0.0.0.0          xe1         connected
20.20.20.0/24       10.10.10.2       xe1         ospf
R1#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                 Code    Session             Out Label   ELC   Nexthop Addr
1.1.1.1/32          E >     non-existent        none        No    connected
2.2.2.2/32          NL>     2.2.2.2             impl-null   No    10.10.10.2
3.3.3.3/32          NL>     2.2.2.2             25601       No    10.10.10.2
10.10.10.0/24       NL      2.2.2.2             impl-null   No    connected
                    E >     non-existent        none        No    connected
20.20.20.0/24       NL>     2.2.2.2             impl-null   No    10.10.10.2
48.48.48.48/32      E >     non-existent        none        No    connected
```

Configure TCP MSS on ALL neighbor

R1 - NSM

R1#configure terminal	Enter configure mode.
R1(config)#interface xe1	Specify the interface xe1 to be configured.
R1(config-if)#ip address 10.10.10.1/24	Assign IP address 10.10.10.1/24 to interface.
R1(config-if)#label-switching	Enable label switching on interface xe1.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface lo	Specify the loopback interface to be configured.
R1(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
R1(config-if)#commit	Commit the transaction.

R1 - LDP

R1(config)#router ldp	Enter Router mode for LDP.
R1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.
R1(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter ipv6 if you are configuring an IPv6 interface.
R1(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
R1(config-router)#neighbor all tcp-mss 700	Configure the TCP MSS value with all neighbor.
R1(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
R1(config-router)#exit	Exit the Router mode and return to the Configure mode.
R1(config)#interface xe1	Enter interface mode xe1.
R1(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R1(config-if)#commit	Commit the transaction.

R1 - OSPF

R1(config)#router ospf 100	Configure the routing process and specify the process ID (100). The process ID should be a unique positive integer identifying the routing process.
R1(config-router)#network 10.10.10.0/24 area 0	Define the interface 10.10.10.0/24, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#network 1.1.1.1/32 area 0	Define the interface 1.1.1.1/32, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#commit	Commit the transaction.

R2 - NSM

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Specify the loopback (lo) interface to be configured.
R2(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#ip address 20.20.20.1/24	Assign IP address 20.20.20.1/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#ip address 10.10.10.2/24	Assign IP address 10.10.10.2/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - LDP

R2(config)#router ldp	Enter Router mode.
R2(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.
R2(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter ipv6 if you are configuring an IPv6 interface.
R2(config-router)#neighbor all tcp-mss 710	Configure the TCP MSS value with all neighbor.
R2(config-router)#exit	Exit Router mode and return to configure mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - OSPF

R2(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
R2(config-router)#network 10.10.10.0/24 area 0	Define the interfaces 10.10.10.0/24, on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID (0) with them.

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R2(config-router)#network 2.2.2.2/32 area 0	Define the interfaces 2.2.2.2/32, on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#commit	Commit the transaction.

R3 - NSM

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Specify the loopback interface to be configured.
R3(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to 3.3.3.3/32.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface xe1	Specify the interface xe1 to be configured.
R3(config-if)#ip address 20.20.20.2/24	Set the IP address of the interface to 20.20.20.2/24.
R3(config-if)#label-switching	Enable label switching on interface xe1.
R3(config-if)#commit	Commit the transaction.

R3 - LDP

R3(config)#router ldp	Enter Router mode.
R3(config-router)#router-id 3.3.3.3	Set the router ID for IP address 3.3.3.3.
R3(config-router)#transport-address ipv4 3.3.3.3	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter ipv6 if you are configuring an IPv6 interface.
R3(config-router)#neighbor all tcp-mss 720	Configure the TCP MSS value with all neighbor.
R3(config-router)#targeted-peer ipv4 1.1.1.1	Configure targeted peer.
R3(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
R3(config-router)#exit	Exit the Router mode and return to the Configure mode.
R3(config)#interface xe1	Enter interface mode.
R3(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R3(config-if)#commit	Commit the transaction.

R3 - OSPF

R3(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
R3(config-router)#network 20.20.20.0/24 area 0	Define the interfaces 20.20.20.0/24, on which OSPF runs and associate the area ID (0) with them.
R3(config-router)#network 3.3.3.3/32 area 0	Define the interfaces 3.3.3.3/32, on which OSPF runs and associate the area ID (0) with them.
R3(config-router)#commit	Commit the transaction.

Validation

R1

```
R1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually
Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       2.2.2.2            xe1        Passive   OPERATIONAL   30    00:11:22
       3.3.3.3            xe1        Passive   OPERATIONAL   30    00:11:22
R1#show ldp session 2.2.2.2
Session state                : OPERATIONAL
Session role                 : Passive
TCP Connection               : Established
IP Address for TCP           : 2.2.2.2
Interface being used         : xe1
Peer LDP ID                  : 2.2.2.2:0
Preferred Peer LDP Password   : Not Set
Adjacencies                  : 10.10.10.2
Advertisement mode           : Downstream Unsolicited
Label retention mode         : Liberal
Graceful Restart             : Not Capable
Keepalive Timeout            : 30
Reconnect Interval           : 15
Configured TCP MSS           : 700
Applied TCP MSS              : 700
Preferred TCP MSS            : NA
Address List received        : 2.2.2.2
                               10.10.10.2
                               20.20.20.1
Received Labels :       Fec             Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:3.3.3.3/32         25601           none
                IPV4:2.2.2.2/32         impl-null       none
Sent Labels :   Fec                     Label           Maps To
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:1.1.1.1/32         impl-null      none
R1#show ldp session 3.3.3.3
Session state                : OPERATIONAL
Session role                 : Passive
TCP Connection               : Established
IP Address for TCP           : 3.3.3.3
Interface being used         : xe1
Peer LDP ID                  : 3.3.3.3:0
Preferred Peer LDP Password   : Not Set
Adjacencies                  : 3.3.3.3
Advertisement mode           : Downstream Unsolicited
```

```
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 700
Applied TCP MSS               : 700
Preferred TCP MSS             : NA
Address List received         : 3.3.3.3
                                20.20.20.2
Received Labels :       Fec             Label           Maps To
Sent Labels :   Fec                     Label           Maps To
```

R2

```
R2#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually
Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       3.3.3.3            xe1        Passive   OPERATIONAL   30    00:13:39
       1.1.1.1            xe2       Active    OPERATIONAL   30    00:13:39
R2#show ldp session 3.3.3.3
Session state                 : OPERATIONAL
Session role                  : Passive
TCP Connection                : Established
IP Address for TCP            : 3.3.3.3
Interface being used          : xe1
Peer LDP ID                   : 3.3.3.3:0
Preferred Peer LDP Password   : Not Set
Adjacencies                   : 20.20.20.2
Advertisement mode            : Downstream Unsolicited
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 710
Applied TCP MSS               : 710
Preferred TCP MSS             : NA
Address List received         : 3.3.3.3
                                20.20.20.2
Received Labels :       Fec             Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:3.3.3.3/32         impl-null       25601
Sent Labels :   Fec                     Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:2.2.2.2/32         impl-null       none
                IPV4:1.1.1.1/32         25600           impl-null
R2#show ldp session 1.1.1.1
Session state                 : OPERATIONAL
```

```
Session role                  : Active
TCP Connection                : Established
IP Address for TCP            : 1.1.1.1
Interface being used          : xe2
Peer LDP ID                   : 1.1.1.1:0
Preferred Peer LDP Password   : Not Set
Adjacencies                   : 10.10.10.1
Advertisement mode            : Downstream Unsolicited
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 710
Applied TCP MSS               : 700
Preferred TCP MSS             : NA
Address List received         : 1.1.1.1
                                10.10.10.1
Received Labels :       Fec             Label           Maps To
                IPV4:48.48.48.48/32     impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:1.1.1.1/32         impl-null       25600
Sent Labels :   Fec                     Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:3.3.3.3/32         25601           impl-null
                IPV4:2.2.2.2/32         impl-null       none
```

R3

```
R3#show ldp session 2.2.2.2
Session state                 : OPERATIONAL
Session role                  : Active
TCP Connection                : Established
IP Address for TCP            : 2.2.2.2
Interface being used          : xe1
Peer LDP ID                   : 2.2.2.2:0
Preferred Peer LDP Password   : Not Set
Adjacencies                   : 20.20.20.1
Advertisement mode            : Downstream Unsolicited
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 720
Applied TCP MSS               : 710
Preferred TCP MSS             : NA
Address List received         : 2.2.2.2
                                10.10.10.2
                                20.20.20.1
Received Labels :       Fec             Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
```

```
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:2.2.2.2/32         impl-null       none
                IPV4:1.1.1.1/32         25600           none
Sent Labels :   Fec                     Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:3.3.3.3/32         impl-null       none
R3#show ldp session 1.1.1.1
Session state                 : OPERATIONAL
Session role                  : Active
TCP Connection                : Established
IP Address for TCP            : 1.1.1.1
Interface being used          : xe1
Peer LDP ID                   : 1.1.1.1:0
Preferred Peer LDP Password   : Not Set
Adjacencies                   : 1.1.1.1
Advertisement mode            : Downstream Unsolicited
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 720
Applied TCP MSS               : 700
Preferred TCP MSS             : NA
Address List received         : 1.1.1.1
                                10.10.10.1
Received Labels :       Fec             Label           Maps To
Sent Labels :   Fec                     Label           Maps To
```

Configuration of TCP MSS with Auto-targeted

R1 - NSM

R1#configure terminal	Enter configure mode.
R1(config)#interface xe1	Specify the interface xe1 to be configured.
R1(config-if)#ip address 10.10.10.1/24	Assign IP address 10.10.10.1/24 to interface.
R1(config-if)#label-switching	Enable label switching on interface xe1.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface lo	Specify the loopback interface to be configured.
R1(config-if)#ip address 1.1.1.1/32 secondary	Set the IP address of the loopback interface to 1.1.1.1/32.
R1(config-if)#commit	Commit the transaction.

R1 - LDP

R1(config)#router ldp	Enter Router mode for LDP.
R1(config-router)#router-id 1.1.1.1	Set the router ID to IP address 1.1.1.1.

R1(config-router)#transport-address ipv4 1.1.1.1	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter ipv6 if you are configuring an IPv6 interface.
R1(config-router)#targeted-peer ipv4 3.3.3.3	Configure targeted peer.
R1(config-router-targeted-peer)#exit	Exit-targeted-peer-mode.
R1(config-router)#exit	Exit the Router mode and return to the configure mode.
R1(config)#interface xe1	Enter interface mode.
R1(config-if)#enable-ldp ipv4	Enable LDP on xe1.
R1(config-if)#commit	Commit the transaction.

R1 - OSPF

R1(config)#router ospf 100	Configure the routing process and specify the process ID (100). The process ID should be a unique positive integer identifying the routing process.
R1(config-router)#network 10.10.10.0/24 area 0	Define the interface 10.10.10.0/24, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#network 1.1.1.1/32 area 0	Define the interface 1.1.1.1/32, on which OSPF runs and associate the area ID (0) with the interface.
R1(config-router)#commit	Commit the transaction.

R2 - NSM

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Specify the loopback interface to be configured.
R2(config-if)#ip address 2.2.2.2/32 secondary	Set the IP address of the loopback interface to 2.2.2.2/32.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe1	Specify the interface xe1 to be configured.
R2(config-if)#ip address 20.20.20.1/24	Assign IP address 20.20.20.1/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe1.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface xe2 to be configured.
R2(config-if)#ip address 10.10.10.2/24	Assign IP address 10.10.10.2/24 to interface.
R2(config-if)#label-switching	Enable label switching on interface xe2.
R2(config-if)#commit	Commit the transaction.

R2 - LDP

R2(config)#router ldp	Enter Router mode.
R2(config-router)#router-id 2.2.2.2	Set the router ID to IP address 2.2.2.2.

R2(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter `ipv6` if you are configuring an IPv6 interface.
R2(config-router)#neighbor auto-targeted tcp-mss 800	Configure the TCP MSS value on all `auto-targeted` neighbors.
R2(config-router)#exit	Exit Router mode and return to configure mode.
R2(config)#interface xe1	Specify the interface `xe1` to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface `xe1`.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface xe2	Specify the interface `xe2` to be configured.
R2(config-if)#enable-ldp ipv4	Enable LDP on a specified interface `xe2`.
R2(config-if)#commit	Commit the transaction.

R2 - OSPF

R2(config)#router ospf 100	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
R2(config-router)#network 10.10.10.0/24 area 0	Define the interfaces `10.10.10.0/24`, on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#network 20.20.20.0/24 area 0	Define the interfaces `20.20.20.0/24`, on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#network 2.2.2.2/32 area 0	Define the interfaces `2.2.2.2/32`, on which OSPF runs and associate the area ID (0) with them.
R2(config-router)#commit	Commit the transaction.

R3 - NSM

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Specify the loopback interface to be configured.
R3(config-if)#ip address 3.3.3.3/32 secondary	Set the IP address of the loopback interface to `3.3.3.3/32`.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface xe1	Specify the interface `xe1` to be configured.
R3(config-if)#ip address 20.20.20.2/24	Set the IP address of the interface to `20.20.20.2/24`.
R3(config-if)#label-switching	Enable label switching on interface `xe1`.
R3(config-if)#commit	Commit the transaction.

R3 - LDP

R3(config)#router ldp	Enter Router mode.
R3(config-router)#router-id 3.3.3.3	Set the router ID for IP address `3.3.3.3`.

`R3(config-router)#transport-address ipv4 3.3.3.3`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface. Note: It is preferable to use the loopback address as transport address. In addition, use the parameter `ipv6` if you are configuring an IPv6 interface.
`R3(config-router)#neighbor auto-targeted tcp-mss 810`	Configure the TCP MSS value on all `auto-targeted` neighbors.
`R3(config-router)#targeted-peer ipv4 1.1.1.1`	Configure targeted peer.
`R3(config-router-targeted-peer)#exit`	Exit-targeted-peer-mode.
`R3(config-router)#exit`	Exit the Router mode and return to the configure mode.
`R3(config)#interface xe1`	Enter interface mode `xe1`.
`R3(config-if)#enable-ldp ipv4`	Enable LDP on `xe1`.
`R3(config-if)#commit`	Commit the transaction.

R3 - OSPF

`R3(config)#router ospf 100`	Configure the routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`R3(config-router)#network 20.20.20.0/24 area 0`	Define the interfaces `20.20.20.0/24`, on which OSPF runs and associate the area ID (0) with them.
`R3(config-router)#network 3.3.3.3/32 area 0`	Define the interfaces `3.3.3.3/32`, on which OSPF runs and associate the area ID (0) with them.
`R3(config-router)#commit`	Commit the transaction.

Validation

R1

```
R1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually
Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       2.2.2.2            xe1        Passive   OPERATIONAL   30    00:00:03
       3.3.3.3            xe1        Passive   OPERATIONAL   30    00:00:03
R1#show ldp targeted-peers
IP Address          Interface
3.3.3.3             xe1
R1#show ldp session 3.3.3.3
Session state                 : OPERATIONAL
Session role                  : Passive
TCP Connection                : Established
IP Address for TCP            : 3.3.3.3
Interface being used          : xe1
```

```
Peer LDP ID                      : 3.3.3.3:0
Preferred Peer LDP Password      : Not Set
Adjacencies                      : 3.3.3.3
Advertisement mode               : Downstream Unsolicited
Label retention mode             : Liberal
Graceful Restart                 : Not Capable
Keepalive Timeout                : 30
Reconnect Interval               : 15
Configured TCP MSS               : Not configured
Applied TCP MSS                  : 810
Preferred TCP MSS                : NA
Address List received            : 3.3.3.3
                                   20.20.20.2
Received Labels :       Fec                Label           Maps To
                IPV4:20.20.20.0/24      25604           none
                IPV4:3.3.3.3/32         25603           none
                IPV4:10.10.10.0/24      25602           none
                IPV4:2.2.2.2/32         25601           none
                IPV4:1.1.1.1/32         25600           none
Sent Labels :   Fec                     Label           Maps To
                IPV4:10.10.10.0/24      25604           none
                IPV4:1.1.1.1/32         25603           none
                IPV4:20.20.20.0/24      25602           impl-null
                IPV4:3.3.3.3/32         25601           25601
                IPV4:2.2.2.2/32         25600           impl-null
```

R2

```
R2#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually
Code  Peer IP Address      IF Name    My Role    State       KeepAlive  UpTime
       3.3.3.3            xe1       Passive   OPERATIONAL   30    00:00:04
       1.1.1.1            xe2       Active    OPERATIONAL   30    00:00:04
R2#show ldp targeted-peers
R2#show ldp session 3.3.3.3
Session state                    : OPERATIONAL
Session role                     : Passive
TCP Connection                   : Established
IP Address for TCP               : 3.3.3.3
Interface being used             : xe1
Peer LDP ID                      : 3.3.3.3:0
Preferred Peer LDP Password      : Not Set
Adjacencies                      : 20.20.20.2
Advertisement mode               : Downstream Unsolicited
Label retention mode             : Liberal
Graceful Restart                 : Not Capable
Keepalive Timeout                : 30
Reconnect Interval               : 15
```

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```
Configured TCP MSS            : Not configured
Applied TCP MSS               : 1460
Preferred TCP MSS             : NA
Address List received         : 3.3.3.3
                                20.20.20.2
Received Labels :       Fec             Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:3.3.3.3/32         impl-null       25601
Sent Labels :   Fec                     Label           Maps To
                IPV4:20.20.20.0/24      impl-null       none
                IPV4:10.10.10.0/24      impl-null       none
                IPV4:2.2.2.2/32         impl-null       none
                IPV4:1.1.1.1/32         25600           impl-null
```

R3

```
R3#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually
Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       2.2.2.2            xe1        Active    OPERATIONAL   30    00:02:15
       1.1.1.1            xe1        Active    OPERATIONAL   30    00:02:15
R3#show ldp targeted-peers
IP Address          Interface
1.1.1.1             xe1
PE2#show ldp session 1.1.1.1
Session state                 : OPERATIONAL
Session role                  : Active
TCP Connection                : Established
IP Address for TCP            : 1.1.1.1
Interface being used          : xe1
Peer LDP ID                   : 1.1.1.1:0
Preferred Peer LDP Password   : Not Set
Adjacencies                   : 1.1.1.1
Advertisement mode            : Downstream Unsolicited
Label retention mode          : Liberal
Graceful Restart              : Not Capable
Keepalive Timeout             : 30
Reconnect Interval            : 15
Configured TCP MSS            : 810
Applied TCP MSS               : 810
Preferred TCP MSS             : NA
Address List received         : 1.1.1.1
                                10.10.10.1
Received Labels :       Fec             Label           Maps To
                                IPV4:10.10.10.0/24      25604           none
                IPV4:1.1.1.1/32         25603           none
                IPV4:20.20.20.0/24      25602           none
                IPV4:3.3.3.3/32         25601           none
```

```
                IPV4:2.2.2.2/32        25600           none
Sent Labels :   Fec                    Label           Maps To
                IPV4:20.20.20.0/24     25604           none
                IPV4:3.3.3.3/32        25603           none
                IPV4:10.10.10.0/24     25602           impl-null
                IPV4:2.2.2.2/32        25601           impl-null
                IPV4:1.1.1.1/32        25600           25600
```

New CLI Command

neighbor tcp-mss

Use this command to set the TCP MSS for an LDP session. MSS is a TCP parameter that defines the maximum amount of data in a TCP segment that can be transmitted.

Use the `no` command to remove the TCP MSS from an LDP session.

Command Syntax

```
neighbor (A.B.C.D| auto-targeted | all) tcp-mss <560-1440>
no neighbor (A.B.C.D | auto-targeted | all) tcp-mss
```

Parameters

`A.B.C.D`	To set MSS for the specific peer.
`auto-targeted`	To set MSS for auto-targeted LDP peer. Auto-targeted LDP sessions automatically establish the TCP connection with neighboring routers and do not require the manual configuration of each peer.
`all`	To set MSS for all LDP peers
`<560-1440>`	Configure the TCP MSS between this range.

Default

By default, `neighbor tcp-mss` is disabled and the MSS value is 1460 bytes.

Command Mode

Router LDP mode.

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
OcNOS(config)#router ldp
OcNOS(config-router)#neighbor 2.2.2.2 tcp-mss 900
OcNOS(config-router)#neighbor all tcp-mss 1000
OcNOS(config-router)#neighbor auto-targeted tcp-mss 800
OcNOS(config-router)#commit
```

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
ACK	Acknowledgment
IGP	Interior Gateway Protocol
LDP	Label Distribution Protocol
MSS	Maximum Segment Size
MTU	Maximum Transmission Unit
OSPF	Open Short Path First
SYN	Synchronize
TCP	Transmission Control Protocol

Glossary

The following provides definitions for key terms used throughout this document:

LDP	LDP is a routing protocol that manages and distributes the labels to the route in a Multiprotocol Label Switching (MPLS) network. Adding a label to a route helps to control the flow of network traffic and increases the forwarding speed, ensuring a smooth and optimized data transmission.
LDP session	LDP session is the connection established between LDP routers in an MPLS network.
MSS	MSS is a TCP parameter that defines the maximum amount of data in a TCP segment that can be transmitted.
TCP	TCP is one of the main protocols in the Internet Protocol (IP) suite. It offers a secure and reliable connection between two devices.
TCP segment	TCP segment is a unit of data transmitted in a TCP connection. The segment consists of header and payload. The header contains the control information to manage the transmission, and the payload contains the actual data that needs to be transmitted.

CHAPTER 6 LDP Remote Loop-Free Alternate (RLFA)

A basic mechanism using Loop-Free Alternates (LFAs) is described in RFC5286 that provides good repair coverage in many topologies, especially those that are highly meshed.

However, some topologies, notably ring-based topologies, are not well protected by LFAs alone. This is because there is no neighbor of the Point of Local Repair (PLR) that has a cost to the destination via a path that does not traverse the failure that is cheaper than the cost to the destination via the failure.

RFC 7490 provides extensions to the basic repair mechanism in which tunnels are used to provide additional logical links that can be used as loop-free alternates where none exist in the original topology. It provides loop-free alternates that guarantee only link protection.

RFC 8102 provides remote-loop-free-based IP fast reroute mechanisms that specifies procedures for determining whether or not a given PQ-node provides node protection for a specific destination. It provides node protection for all destinations covered by the same remote-LFA alternate, in case of failure of the primary next-hop node

ISIS shall compute PQ node and LDP shall dynamically create tunnel to PQ node so that if primary path fails traffic can be rerouted to backup rLFA tunnel and hence to destination.

Remote LFA involves the use of a tunnel to a next-hop that is not directly connected. This is the primary difference between the LFA and Remote LFA.

RLFA Terminology

Terms used for defining tunnel as below:

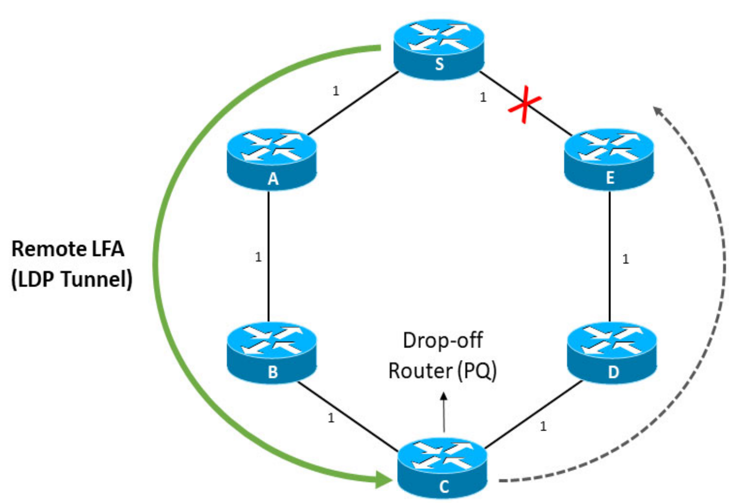

Figure 6-6: Understanding RLFA

Repair tunnel

A tunnel established for the purpose of providing a virtual neighbor that is a Loop-Free Alternate.

P-space

The P-space of a router with respect to a protected link is the set of routers reachable from that specific router using the pre-convergence shortest paths, without any of those paths (including equal cost path splits) transiting that protected link.

For example, the P-space of S with respect to link S-E is the set of routers that S can reach without using the protected link S-E.

Extended P-space

Consider the set of neighbors of a router protecting a link. Exclude the router reachable over the protected link from that set of routers. The extended P-space of the protecting router with respect to the protected link is the union of the P spaces of the neighbors in that set of neighbors with respect to the protected link.

Q-space

Q-space of a router with respect to a protected link is the set of routers from which that specific router that can be reached without any path (including ECMP Splits) transiting that protected link.

PQ node

A PQ node of a node S with respect to a protected link S-E is a node that is a member of both the P-space (or the extended P-space) of S with respect to that protected link S-E and the Q-space of E with respect to that protected link S-E. A repair tunnel endpoint is chosen from the set of PQ-nodes.

Remote LFA (RLFA)

The use of a PQ node rather than a neighbor of the repairing node as the next hop in an LFA repair.

In Figure 6-6, S can reach A, B, and C without going via S-E; these form S's extended P-space with respect to S-E. The routers that can reach E without going through S-E will be in E's Q-space with respect to link S-E; these are D and C.B has equal-cost paths to E via B-A-S-E and B-C-D-E, and so the forwarder at S might choose to send a packet to E via link S-E. Hence, B is not in the Q-space of E with respect to link S-E. The single node in both S's extended P-space and E's Q-space is C; thus, node C is selected as the repair tunnel's endpoint. Thus, if a tunnel is provided between S and C as shown in Figure 2, then C, now being a direct neighbor of S, would become an LFA for D and E.

Establishing RLFA Tunnel

To calculate the Remote LFA backup path and to determines the Remote LFA node the software requirement can be broadly classified as below:

IS-IS

ISIS shall calculate Repair path that are P space (routers it can reach without traversing the protected link) and Q space (routers that can reach the protected destination without traversing the protected link). Hence routers that belong to both spaces called as PQ routers has to be calculated. It has to inform LDP about PQ node so that RLFA tunnel can be established.

LDP

LDP shall establish targeted session with PQ node and shall advertise label to peer node for the destination FEC. LDP shall send primary and backup path FTN/ILM add/delete info to NSM for further programing.

NSM

NSM shall maintain Primary and Backup path FTN/ILM and shall send information to HSL for data-plane programing.

HSL

HSL program primary and backup FTN/ILM entry in hardware.

Configure LDP Remote Loop-Free Alternate (RLFA)

The LDP RLFA configuration process can be divided into the following tasks:

1. Enable label-switching on the interface on NSM.
2. Establish ISIS routing between the nodes (to distribute reachability information within the MPLS cloud)
3. Configure ISIS RLFA on Source node
4. Enabling LDP on an interface in the LDP daemon
5. Configure LDP FRR with Auto-targeted-session (Allow creating TLDP session dynamically)
6. Enable BFD interval globally and for all ISIS enabled interfaces

Note: Faster convergence can be achieved with lower BFD interval enabled globally.

Note: Dynamically created RLFA T-LDP sessions will be removed only after disabling LDP `auto-targeted-session` CLI or LDP FRR.

Note: When `targeted-peer ipv4` CLI is configured with `auto-targeted-session` CLI, T-LDP session created for targeted-peer only remove after disabling `auto-targeted-session` CLI.

Note: After Enabling ISIS RLFA, Both LFA and RLFA computation will be done and RLFA path will be preferred to provide node-protection.

Note: Better convergence can be achieved with LDP-IGP-SYNC enabled.

Assumptions and limitations

- RLFA Backup path computation will be supported only via IGP as IS-IS.
- Only LDP(MPLS) will be used as a tunnel mechanism to reach a Remote-LFA repair node.
- Only IPv4 protocol is supported.
- RFC 7916 [LFA-MANAGE] is not supported.
- ECMP will not be supported for RLFA next-hop.

Topology

Figure 6-7 shows the configuration required to enable the RLFA feature.

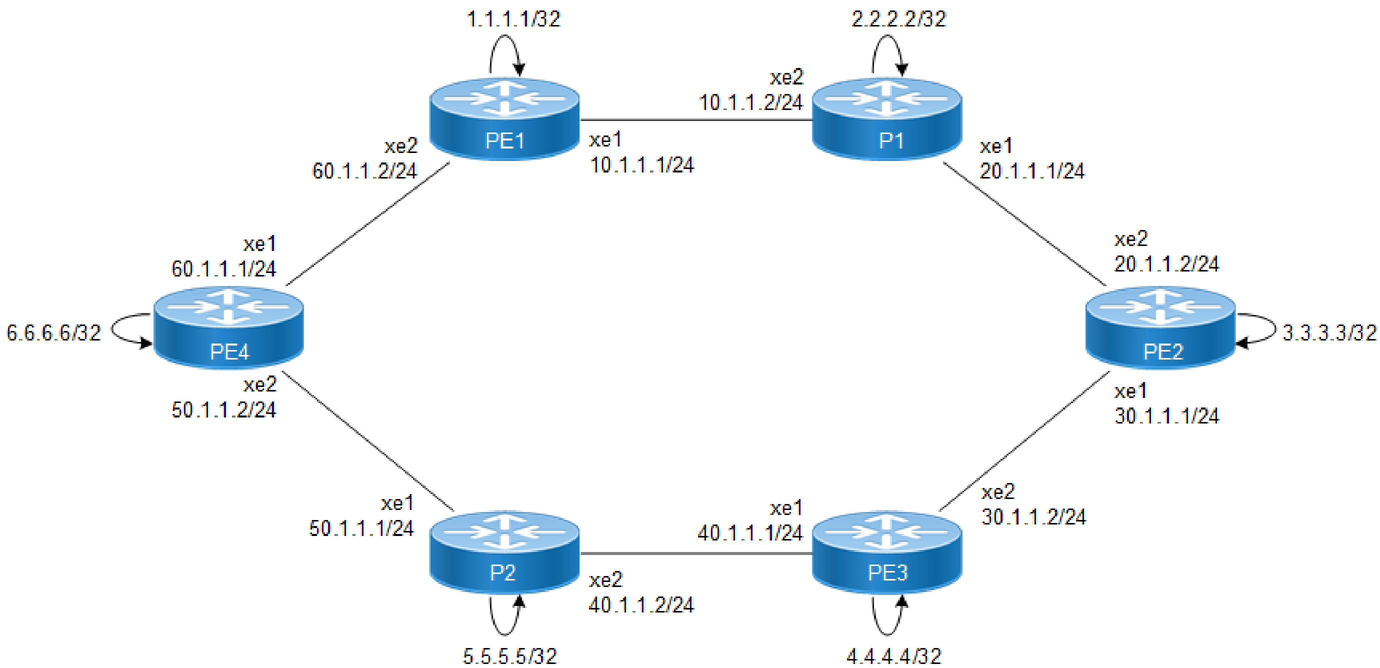

Figure 6-7: RLFA Topology

Configuration

PE1

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enable LDP process
`(config-router)#fast-reroute`	Enable LDP FRR
`(config-router)#auto-targeted-session`	To Allow creating TLDP session dynamically
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit LDP process
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.1.1.1/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa)
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe1 interface
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 60.1.1.2/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa).
`(config-if)#label-switching`	Enable label-switching on interface

(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 1.1.1.1	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0001.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# fast-reroute per-prefix remote-lfa level-1 proto ipv4 tunnel mpls-ldp	Configure Remote LFA to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#end	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally

P1

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.

(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 1.1.1.1	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0002.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration

PE2

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa)

(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 30.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 3.3.3.3/32 secondary	Configure the IP address of the interface
(config-if)#ip router isis rlfa	Enable IS-IS routing on an interface for area 49 (rlfa).
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#router isis rlfa	Create an IS-IS routing instance for area 49 (rlfa).
(config-router)#is-type level-1	Configure instance as level-1-only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1.
(config-router)# mpls traffic-eng router-id 3.3.3.3	Configure MPLS-TE unique router-id TLV.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance.
(config-router)# net 49.0000.0000.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)# bfd all-interfaces	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration

PE3

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically

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`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit LDP process
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 30.1.1.2/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa)
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe2 interface
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 40.1.1.1/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa).
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe1 interface
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 4.4.4.4/32 secondary`	Configure the IP address of the interface
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa).
`(config-if)#exit`	Exit interface mode.
`(config)#router isis rlfa`	Create an IS-IS routing instance for area 49 (rlfa).
`(config-router)#is-type level-1`	Configure instance as level-1-only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide.
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1.
`(config-router)# mpls traffic-eng router-id 4.4.4.4`	Configure MPLS-TE unique router-id TLV.
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance.
`(config-router)# net 49.0000.0000.0004.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID.
`(config-router)# bfd all-interfaces`	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit router mode.
`(config)# bfd interval 3 minrx 3 multiplier 3`	Configure bfd interval globally
`(config)#commit`	Commit the candidate configuration to the running configuration

P2

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enable LDP process
`(config-router)#fast-reroute`	Enable LDP FRR
`(config-router)#auto-targeted-session`	To Allow creating TLDP session dynamically
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit LDP process
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 40.1.1.2/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa)
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe2 interface
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 50.1.1.1/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa).
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe1 interface
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 5.5.5.5/32 secondary`	Configure the IP address of the interface
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa).
`(config-if)#exit`	Exit interface mode.
`(config)#router isis rlfa`	Create an IS-IS routing instance for area 49 (rlfa).
`(config-router)#is-type level-1`	Configure instance as level-1-only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide.
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1.
`(config-router)# mpls traffic-eng router-id 5.5.5.5`	Configure MPLS-TE unique router-id TLV.
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance.
`(config-router)# net 49.0000.0000.0005.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID.
`(config-router)# bfd all-interfaces`	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit router mode.

`(config)# bfd interval 3 minrx 3 multiplier 3`	Configure bfd interval globally
`(config)#commit`	Commit the candidate configuration to the running configuration

PE4

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enable LDP process
`(config-router)#fast-reroute`	Enable LDP FRR
`(config-router)#auto-targeted-session`	To Allow creating TLDP session dynamically
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit LDP process
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 50.1.1.2/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa)
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe2 interface
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 60.1.1.1/24`	Configure the IP address of the interface.
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa).
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe1 interface
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 6.6.6.6/32 secondary`	Configure the IP address of the interface
`(config-if)#ip router isis rlfa`	Enable IS-IS routing on an interface for area 49 (rlfa).
`(config-if)#exit`	Exit interface mode.
`(config)#router isis rlfa`	Create an IS-IS routing instance for area 49 (rlfa).
`(config-router)#is-type level-1`	Configure instance as level-1-only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide.
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1.
`(config-router)# mpls traffic-eng router-id 6.6.6.6`	Configure MPLS-TE unique router-id TLV.
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance.
`(config-router)# net 49.0000.0000.0005.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID.

`(config-router)# bfd all-interfaces`	Enable the Bidirectional Forwarding Detection (BFD) feature on the interfaces enabled with this ISIS instance.
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit router mode.
`(config)# bfd interval 3 minrx 3 multiplier 3`	Configure bfd interval globally
`(config)#commit`	Commit the candidate configuration to the running configuration

Validation

PE1

Check LDP neighborship before enabling RLFA

```
PE1#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
2.2.2.2                  xe1        Passive   OPERATIONAL   30    00:02:19
6.6.6.6                  xe2        Passive   OPERATIONAL   30    00:02:19
```

Check the output of "show clns neighbors" to verify that ISIS adjacency is up.

```
PE1#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa:  VRF : default
System Id      Interface   SNPA                State  Holdtime   Type Protocol
0000.0000.0006 xe2         e8c5.7a78.7132      Up     23         L1   IS-IS
0000.0000.0002 xe1         e8c5.7a98.c48a      Up     23         L1   IS-IS
```

Check the ISIS route installation in the ISIS table and RIB table.

```
PE1#show ip isis route

Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, D - discard, e - external metric
       ** - invalid

Tag rlfa:  VRF : default
     Destination         Metric      Next-Hop            Interface      Tag
C    1.1.1.1/32          10          --                  lo            0
L1   2.2.2.2/32          20          10.1.1.2            xe1             0
L1   3.3.3.3/32          30          10.1.1.2            xe1             0
L1   4.4.4.4/32          40          10.1.1.2            xe1             0
                                     60.1.1.1            xe2             0
L1   5.5.5.5/32          30          60.1.1.1            xe2             0
L1   6.6.6.6/32          20          60.1.1.1            xe2             0
```

```
C    10.1.1.0/24         10          --                  xe1           0
L1   20.1.1.0/24         20          10.1.1.2            xe1           0
L1   30.1.1.0/24         30          10.1.1.2            xe1           0
L1   40.1.1.0/24         30          60.1.1.1            xe2           0
L1   50.1.1.0/24         20          60.1.1.1            xe2           0
C    60.1.1.0/24         10          --                  xe2           0

PE1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
C            1.1.1.1/32 is directly connected, lo, 01:52:43
i L1         2.2.2.2/32 [115/20] via 10.1.1.2, xe1, 00:27:36
i L1         3.3.3.3/32 [115/30] via 10.1.1.2, xe1, 00:27:36
i L1         4.4.4.4/32 [115/40] via 60.1.1.1, xe2, 00:27:36
                        [115/40] via 10.1.1.2, xe1
i L1         5.5.5.5/32 [115/30] via 60.1.1.1, xe2, 00:27:36
i L1         6.6.6.6/32 [115/20] via 60.1.1.1, xe2, 00:27:36
C            10.1.1.0/24 is directly connected, xe1, 01:52:42
i L1         20.1.1.0/24 [115/20] via 10.1.1.2, xe1, 00:27:36
i L1         30.1.1.0/24 [115/30] via 10.1.1.2, xe1, 00:27:36
i L1         40.1.1.0/24 [115/30] via 60.1.1.1, xe2, 00:27:36
i L1         50.1.1.0/24 [115/20] via 60.1.1.1, xe2, 00:27:36
C            60.1.1.0/24 is directly connected, xe2, 01:52:42
C            127.0.0.0/8 is directly connected, lo, 01:54:18

Gateway of last resort is not set
```

Verify ISIS LFA and RLFA backup computed paths for Primary Paths

```
PE1# show ip isis route fast-reroute

Tag   : rlfa  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area,
        D - discard, LP - Link Protecting, NP - Node Protecting,
        BP - Broadcast Interface Disjoint, Pri - Primary Path,
        Sec - Secondary Path, DP - Downstream Path

L1  2.2.2.2/32
    Primary Path via    : 10.1.1.2, xe1
    Remote FRR Path via : 4.4.4.4, via : 60.1.1.1, xe2
    FRR Metric          : 60
    Protection Provided : LP
```

```
L1  3.3.3.3/32
    Primary Path via    : 10.1.1.2, xe1
    Remote FRR Path via : 4.4.4.4, via : 60.1.1.1, xe2
    FRR Metric          : 50
    Protection Provided : LP NP DP

L1  4.4.4.4/32
    Primary Path via    : 10.1.1.2, xe1
    FRR Backup Path via : 60.1.1.1, xe2
    FRR Metric          : 40
    Protection Provided : LP NP BP Pri DP

    Primary Path via    : 60.1.1.1, xe2
    FRR Backup Path via : 10.1.1.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP Pri DP

L1  5.5.5.5/32
    Primary Path via    : 60.1.1.1, xe2
    Remote FRR Path via : 4.4.4.4, via : 10.1.1.2, xe1
    FRR Metric          : 50
    Protection Provided : LP NP DP

L1  6.6.6.6/32
    Primary Path via    : 60.1.1.1, xe2
    Remote FRR Path via : 4.4.4.4, via : 10.1.1.2, xe1
    FRR Metric          : 60
    Protection Provided : LP

L1  20.1.1.0/24
    Primary Path via    : 10.1.1.2, xe1
    Remote FRR Path via : 4.4.4.4, via : 60.1.1.1, xe2
    FRR Metric          : 60
    Protection Provided : LP

L1  30.1.1.0/24
    Primary Path via    : 10.1.1.2, xe1
    FRR Backup Path via : 60.1.1.1, xe2
    FRR Metric          : 40
    Protection Provided : LP NP BP

L1  40.1.1.0/24
    Primary Path via    : 60.1.1.1, xe2
    FRR Backup Path via : 10.1.1.2, xe1
    FRR Metric          : 40
    Protection Provided : LP NP BP

L1  50.1.1.0/24
    Primary Path via    : 60.1.1.1, xe2
```

```
    Remote FRR Path via : 4.4.4.4, via : 10.1.1.2, xe1
    FRR Metric          : 60
    Protection Provided : LP
```

Verify PQ node which is near to source is selected and Target-LDP session is established with PQ node using below commands

```
PE1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
2.2.2.2                   xe2        Passive   OPERATIONAL   30    00:05:37
6.6.6.6                   xe1        Passive   OPERATIONAL   30    00:05:37
4.4.4.4                   xe1        Passive   OPERATIONAL   30    00:05:21

PE1#show ldp targeted-peers
IP Address          Interface
4.4.4.4             xe1   > PE1 established T-LDP with PE3 (since PE3 is PQ for PE1)
```

Verify that Primary and Backup FTN's are installed with labels in LDP RLFA route table

```
PE1#sh ldp rlfa-routes
Fec             Primary-NH      Backup-NH       rLFA-Addr       Out-Intf  Outer-label
Inner-label

2.2.2.2        10.1.1.2       60.1.1.1       4.4.4.4        xe1      24962       24329
3.3.3.3        10.1.1.2       60.1.1.1       4.4.4.4        xe1      24962       24330
5.5.5.5        60.1.1.1       10.1.1.2       4.4.4.4        xe2      24321       24331
6.6.6.6        60.1.1.1       10.1.1.2       4.4.4.4        xe2      24321       24332
20.1.1.0       10.1.1.2       60.1.1.1       4.4.4.4        xe1      24962       24334
50.1.1.0       60.1.1.1       10.1.1.2       4.4.4.4        xe2      24321       24335
```

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

```
PE1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1        2        -          Yes   LSP_DEFAULT  3
xe1        No    10.1.1.2
                                    29       -          No    LSP_DEFAULT  24329
xe2        No    4.4.4.4
                                                                                     (via
60.1.1.1 ,label 24962)
   L>   3.3.3.3/32         3        10       -          Yes   LSP_DEFAULT  24320
xe1        No    10.1.1.2
```

```
                                30        -          No    LSP_DEFAULT  24330
xe2        No    4.4.4.4
                                                                                (via
60.1.1.1 ,label 24962)
   L>   4.4.4.4/32        2      8        -          Yes   LSP_DEFAULT  24962
xe2        No    60.1.1.1
                                11        -          No    LSP_DEFAULT  24321
xe1        No    10.1.1.2
                                11        -          Yes   LSP_DEFAULT  24321
xe1        No    10.1.1.2
                                7         -          No    LSP_DEFAULT  24962
xe2        No    60.1.1.1
   L>   5.5.5.5/32        4      14       -          Yes   LSP_DEFAULT  24963
xe2        No    60.1.1.1
                                31        -          No    LSP_DEFAULT  24331
xe1        No    4.4.4.4
                                                                                (via
10.1.1.2 ,label 24321)
   L>   6.6.6.6/32        5      18       -          Yes   LSP_DEFAULT  3
xe2        No    60.1.1.1
                                32        -          No    LSP_DEFAULT  24332
xe1        No    4.4.4.4
                                                                                (via
10.1.1.2 ,label 24321)
   L>   20.1.1.0/24       6      19       -          Yes   LSP_DEFAULT  3
xe1        No    10.1.1.2
                                33        -          No    LSP_DEFAULT  24334
xe2        No    4.4.4.4
                                                                                (via
60.1.1.1 ,label 24962)
   L>   30.1.1.0/24       7      21       -          Yes   LSP_DEFAULT  24322
xe1        No    10.1.1.2
                                22        -          No    LSP_DEFAULT  24964
xe2        No    60.1.1.1
   L>   40.1.1.0/24       8      25       -          Yes   LSP_DEFAULT  24965
xe2        No    60.1.1.1
                                26        -          No    LSP_DEFAULT  24323
xe1        No    10.1.1.2
   L>   50.1.1.0/24       9      28       -          Yes   LSP_DEFAULT  3
xe2        No    60.1.1.1
                                34        -          No    LSP_DEFAULT  24335
xe1        No    4.4.4.4
                                                                                (via
10.1.1.2 ,label 24321)


PE1#sh mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 2, op code: Push
```

```
     Backup Cross connect ix: 6, in intf: - in label: 0  out-segment ix: 29
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 29, owner: LDP, Stale: NO, out intf: xe2, out label: 24329
    Nexthop addr: 4.4.4.4        cross connect ix: 5, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe1, out label: 24320
    Nexthop addr: 10.1.1.2        cross connect ix: 7, op code: Push

     Backup Cross connect ix: 8, in intf: - in label: 0  out-segment ix: 30
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 30, owner: LDP, Stale: NO, out intf: xe2, out label: 24330
    Nexthop addr: 4.4.4.4        cross connect ix: 7, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 24962
    Nexthop addr: 60.1.1.1        cross connect ix: 3, op code: Push

     Backup Cross connect ix: 2, in intf: - in label: 0  out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 24321
    Nexthop addr: 10.1.1.2        cross connect ix: 3, op code: Push

     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 11
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: xe1, out label: 24321
    Nexthop addr: 10.1.1.2        cross connect ix: 3, op code: Push

     Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 7
      Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
       Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 24962
    Nexthop addr: 60.1.1.1        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 5.5.5.5/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 13
```

```
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 13, owner: LDP, Stale: NO, out intf: xe2, out label: 24963
    Nexthop addr: 60.1.1.1        cross connect ix: 8, op code: Push

     Backup Cross connect ix: 10, in intf: - in label: 0  out-segment ix: 31
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 31, owner: LDP, Stale: NO, out intf: xe1, out label: 24331
    Nexthop addr: 4.4.4.4        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 6.6.6.6/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 16
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 16, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 60.1.1.1        cross connect ix: 9, op code: Push

     Backup Cross connect ix: 12, in intf: - in label: 0  out-segment ix: 32
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 32, owner: LDP, Stale: NO, out intf: xe1, out label: 24332
    Nexthop addr: 4.4.4.4        cross connect ix: 11, op code: Push


 Primary FTN entry with FEC: 20.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 2, op code: Push

     Backup Cross connect ix: 14, in intf: - in label: 0  out-segment ix: 33
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 33, owner: LDP, Stale: NO, out intf: xe2, out label: 24334
    Nexthop addr: 4.4.4.4        cross connect ix: 13, op code: Push


 Primary FTN entry with FEC: 30.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 20
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 20, owner: LDP, Stale: NO, out intf: xe1, out label: 24322
    Nexthop addr: 10.1.1.2        cross connect ix: 11, op code: Push

     Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 22
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
       Out-segment with ix: 22, owner: LDP, Stale: NO, out intf: xe2, out label: 24964
    Nexthop addr: 60.1.1.1        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 40.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 12, in intf: - in label: 0 out-segment ix: 24
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 24, owner: LDP, Stale: NO, out intf: xe2, out label: 24965
    Nexthop addr: 60.1.1.1        cross connect ix: 12, op code: Push

     Backup Cross connect ix: 4, in intf: - in label: 0  out-segment ix: 26
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 26, owner: LDP, Stale: NO, out intf: xe1, out label: 24323
    Nexthop addr: 10.1.1.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 50.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 16
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 16, owner: N/A, Stale: NO, out intf: xe2, out label: 3
    Nexthop addr: 60.1.1.1        cross connect ix: 9, op code: Push

     Backup Cross connect ix: 16, in intf: - in label: 0  out-segment ix: 34
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 34, owner: LDP, Stale: NO, out intf: xe1, out label: 24335
    Nexthop addr: 4.4.4.4        cross connect ix: 15, op code: Push
P1#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
1.1.1.1 xe2 Active OPERATIONAL 30 00:51:02
3.3.3.3 xe1 Passive OPERATIONAL 30 00:50:53
P1#
P1#
P1#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
PE1 xe2 5254.0073.cecf Up 6 L1 IS-IS
 PE2 xe1 5254.0084.60d4 Up 22 L1 IS-IS
P1#
Check the ISIS route installation in the ISIS table and RIB table.
P1#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
```

```
** - invalid
Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 20 10.1.1.1 xe2 0
C 2.2.2.2/32 10 -- lo 0
L1 3.3.3.3/32 20 20.1.1.2 xe1 0
L1 4.4.4.4/32 30 20.1.1.2 xe1 0
L1 5.5.5.5/32 40 20.1.1.2 xe1 0
10.1.1.1 xe2 0
L1 6.6.6.6/32 30 10.1.1.1 xe2 0
C 10.1.1.0/24 10 -- xe2 0
C 20.1.1.0/24 10 -- xe1 0
L1 30.1.1.0/24 20 20.1.1.2 xe1 0
L1 40.1.1.0/24 30 20.1.1.2 xe1 0
L1 50.1.1.0/24 30 10.1.1.1 xe2 0
L1 60.1.1.0/24 20 10.1.1.1 xe2 0
P1#
P1#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, eth0
i L1 1.1.1.1/32 [115/20] via 10.1.1.1, xe2, 00:55:27
C 2.2.2.2/32 is directly connected, lo, 01:00:19
i L1 3.3.3.3/32 [115/20] via 20.1.1.2, xe1, 00:55:15
i L1 4.4.4.4/32 [115/30] via 20.1.1.2, xe1, 00:55:15
i L1 5.5.5.5/32 [115/40] via 10.1.1.1, xe2, 00:55:15
[115/40] via 20.1.1.2, xe1
i L1 6.6.6.6/32 [115/30] via 10.1.1.1, xe2, 00:55:03
C 10.1.1.0/24 is directly connected, xe2, 01:00:19
C 10.12.49.0/24 is directly connected, xe0, 01:06:48
C 20.1.1.0/24 is directly connected, xe1, 01:00:19
i L1 30.1.1.0/24 [115/20] via 20.1.1.2, xe1, 00:55:15
i L1 40.1.1.0/24 [115/30] via 20.1.1.2, xe1, 00:55:15
i L1 50.1.1.0/24 [115/30] via 10.1.1.1, xe2, 00:55:03
i L1 60.1.1.0/24 [115/20] via 10.1.1.1, xe2, 00:55:27
C 127.0.0.0/8 is directly connected, lo, 01:12:47
P1#show ldp targeted-peers
IP Address Interface
1.1.1.1 xe2
3.3.3.3 xe1
P1#
P1#
```

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

```
P1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 1 1 - Yes LSP_DEFAULT 3 xe2 No 10.1.1.1
L> 3.3.3.3/32 3 2 - Yes LSP_DEFAULT 3 xe1 No 20.1.1.2
L> 4.4.4.4/32 4 3 - Yes LSP_DEFAULT 25600 xe1 No 20.1.1.2
L> 5.5.5.5/32 5 4 - Yes LSP_DEFAULT 25601 xe1 No 20.1.1.2
7 - Yes LSP_DEFAULT 25600 xe2 No 10.1.1.1
L> 6.6.6.6/32 9 8 - Yes LSP_DEFAULT 25601 xe2 No 10.1.1.1
L> 30.1.1.0/24 6 2 - Yes LSP_DEFAULT 3 xe1 No 20.1.1.2
L> 40.1.1.0/24 7 5 - Yes LSP_DEFAULT 25602 xe1 No 20.1.1.2
L> 50.1.1.0/24 8 9 - Yes LSP_DEFAULT 25603 xe2 No 10.1.1.1
L> 60.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe2 No 10.1.1.1
P1#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.1.1.1 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 20.1.1.2 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 4.4.4.4/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 20.1.1.2 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 5.5.5.5/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
```

```
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
Nexthop addr: 20.1.1.2 cross connect ix: 5, op code: Push
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
Nexthop addr: 10.1.1.1 cross connect ix: 5, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25601
Nexthop addr: 10.1.1.1 cross connect ix: 8, op code: Push
Primary FTN entry with FEC: 30.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 20.1.1.2 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 40.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25602
Nexthop addr: 20.1.1.2 cross connect ix: 6, op code: Push
Primary FTN entry with FEC: 50.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 9
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe2, out label: 25603
Nexthop addr: 10.1.1.1 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
```

```
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.1.1.1 cross connect ix: 1, op code: Push
P1#
PE2#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
2.2.2.2 xe2 Active OPERATIONAL 30 01:14:28
4.4.4.4 xe1 Passive OPERATIONAL 30 01:14:27
PE2#
PE2#
PE2#
PE2#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
P1 xe2 5254.00a6.9d27 Up 9 L1 IS-IS
PE3 xe1 5254.0076.2129 Up 21 L1 IS-IS
PE2#
Check the ISIS route installation in the ISIS table and RIB table.
PE2#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid

Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 30 20.1.1.1 xe2 0
L1 2.2.2.2/32 20 20.1.1.1 xe2 0
C 3.3.3.3/32 10 -- lo 0
L1 4.4.4.4/32 20 30.1.1.2 xe1 0
L1 5.5.5.5/32 30 30.1.1.2 xe1 0
L1 6.6.6.6/32 40 30.1.1.2 xe1 0
20.1.1.1 xe2 0
L1 10.1.1.0/24 20 20.1.1.1 xe2 0
C 20.1.1.0/24 10 -- xe2 0
C 30.1.1.0/24 10 -- xe1 0
L1 40.1.1.0/24 20 30.1.1.2 xe1 0
L1 50.1.1.0/24 30 30.1.1.2 xe1 0
L1 60.1.1.0/24 30 20.1.1.1 xe2 0
PE2#
PE2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
```

```
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, xe0
i L1 1.1.1.1/32 [115/30] via 20.1.1.1, xe2, 01:18:10
i L1 2.2.2.2/32 [115/20] via 20.1.1.1, xe2, 01:18:31
C 3.3.3.3/32 is directly connected, lo, 01:23:03
i L1 4.4.4.4/32 [115/20] via 30.1.1.2, xe1, 01:18:23
i L1 5.5.5.5/32 [115/30] via 30.1.1.2, xe1, 01:18:23
i L1 6.6.6.6/32 [115/40] via 20.1.1.1, xe2, 01:18:10
[115/40] via 30.1.1.2, xe1
i L1 10.1.1.0/24 [115/20] via 20.1.1.1, xe2, 01:18:31
C 10.12.49.0/24 is directly connected, xe0, 01:29:05
C 20.1.1.0/24 is directly connected, xe2, 01:23:03
C 30.1.1.0/24 is directly connected, xe1, 01:23:03
i L1 40.1.1.0/24 [115/20] via 30.1.1.2, xe1, 01:18:23
i L1 50.1.1.0/24 [115/30] via 30.1.1.2, xe1, 01:18:23
i L1 60.1.1.0/24 [115/30] via 20.1.1.1, xe2, 01:18:10
C 127.0.0.0/8 is directly connected, lo, 01:35:42
PE2#
PE2#show ldp targeted-peers
IP Address Interface
2.2.2.2 xe2

PE2#
Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify
the same in FTN table.
PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 7 5 - Yes LSP_DEFAULT 25606 xe2 No 20.1.1.1
L> 2.2.2.2/32 1 1 - Yes LSP_DEFAULT 3 xe2 No 20.1.1.1
L> 4.4.4.4/32 3 2 - Yes LSP_DEFAULT 3 xe1 No 30.1.1.2
L> 5.5.5.5/32 4 3 - Yes LSP_DEFAULT 25602 xe1 No 30.1.1.2
L> 6.6.6.6/32 9 7 - Yes LSP_DEFAULT 25608 xe2 No 20.1.1.1
8 - Yes LSP_DEFAULT 25605 xe1 No 30.1.1.2
L> 10.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe2 No 20.1.1.1
L> 40.1.1.0/24 5 2 - Yes LSP_DEFAULT 3 xe1 No 30.1.1.2
L> 50.1.1.0/24 6 4 - Yes LSP_DEFAULT 25603 xe1 No 30.1.1.2
L> 60.1.1.0/24 8 6 - Yes LSP_DEFAULT 25607 xe2 No 20.1.1.1
PE2#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:40577, pkts:634, TX bytes:43113, Pushed pkts:634
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25606
Nexthop addr: 20.1.1.1 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 20.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 30.1.1.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 5.5.5.5/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe1, out label: 25602
Nexthop addr: 30.1.1.2 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe2, out label: 25608
Nexthop addr: 20.1.1.1 cross connect ix: 7, op code: Push
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25605
Nexthop addr: 30.1.1.2 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 10.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe2, out label: 3
```

```
Nexthop addr: 20.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 40.1.1.0/24, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 30.1.1.2 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 50.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up

Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25603
Nexthop addr: 30.1.1.2 cross connect ix: 5, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25607
Nexthop addr: 20.1.1.1 cross connect ix: 6, op code: Push
PE2#
PE3#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
5.5.5.5 xe1 Passive OPERATIONAL 30 01:47:18
3.3.3.3 xe2 Active OPERATIONAL 30 01:47:18
1.1.1.1 xe1 Active OPERATIONAL 30 01:11:17
PE3#
PE3#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
PE2 xe2 5254.0087.a49f Up 8 L1 IS-IS
P2 xe1 5254.0030.e9d0 Up 7 L1 IS-IS
PE3#
Check the ISIS route installation in the ISIS table and RIB table.
PE3#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid
Tag rlfa: VRF : default
```

```
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 40 40.1.1.2 xe1 0
30.1.1.1 xe2 0
L1 2.2.2.2/32 30 30.1.1.1 xe2 0
L1 3.3.3.3/32 20 30.1.1.1 xe2 0
C 4.4.4.4/32 10 -- lo 0
L1 5.5.5.5/32 20 40.1.1.2 xe1 0
L1 6.6.6.6/32 30 40.1.1.2 xe1 0
L1 10.1.1.0/24 30 30.1.1.1 xe2 0
L1 20.1.1.0/24 20 30.1.1.1 xe2 0

C 30.1.1.0/24 10 -- xe2 0
C 40.1.1.0/24 10 -- xe1 0
L1 50.1.1.0/24 20 40.1.1.2 xe1 0
L1 60.1.1.0/24 30 40.1.1.2 xe1 0
PE3#
PE3#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, xe0
i L1 1.1.1.1/32 [115/40] via 30.1.1.1, xe2, 01:49:09
[115/40] via 40.1.1.2, xe1
i L1 2.2.2.2/32 [115/30] via 30.1.1.1, xe2, 01:49:09
i L1 3.3.3.3/32 [115/20] via 30.1.1.1, xe2, 01:49:21
C 4.4.4.4/32 is directly connected, lo, 01:53:34
i L1 5.5.5.5/32 [115/20] via 40.1.1.2, xe1, 01:49:21
i L1 6.6.6.6/32 [115/30] via 40.1.1.2, xe1, 01:49:09
i L1 10.1.1.0/24 [115/30] via 30.1.1.1, xe2, 01:49:09
C 10.12.49.0/24 is directly connected, xe0, 01:58:31
i L1 20.1.1.0/24 [115/20] via 30.1.1.1, xe2, 01:49:21
C 30.1.1.0/24 is directly connected, xe2, 01:53:34
C 40.1.1.0/24 is directly connected, xe1, 01:53:34
i L1 50.1.1.0/24 [115/20] via 40.1.1.2, xe1, 01:49:21
i L1 60.1.1.0/24 [115/30] via 40.1.1.2, xe1, 01:49:09
C 127.0.0.0/8 is directly connected, lo, 02:06:35
PE3#
PE3#show ldp targeted-peers
IP Address Interface
1.1.1.1 xe2
5.5.5.5 xe1
PE3#
```

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

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```
PE3#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 5 3 - Yes LSP_DEFAULT 25606 xe2 No 30.1.1.1
6 - Yes LSP_DEFAULT 25600 xe1 No 40.1.1.2
L> 2.2.2.2/32 6 4 - Yes LSP_DEFAULT 25604 xe2 No 30.1.1.1
L> 3.3.3.3/32 3 2 - Yes LSP_DEFAULT 3 xe2 No 30.1.1.1
L> 5.5.5.5/32 1 1 - Yes LSP_DEFAULT 3 xe1 No 40.1.1.2
L> 6.6.6.6/32 8 7 - Yes LSP_DEFAULT 25601 xe1 No 40.1.1.2
L> 10.1.1.0/24 7 5 - Yes LSP_DEFAULT 25605 xe2 No 30.1.1.1
L> 20.1.1.0/24 4 2 - Yes LSP_DEFAULT 3 xe2 No 30.1.1.1
L> 50.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe1 No 40.1.1.2
L> 60.1.1.0/24 9 8 - Yes LSP_DEFAULT 25603 xe1 No 40.1.1.2
PE3#
PE3#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe2, out label: 25606
Nexthop addr: 30.1.1.1 cross connect ix: 1, op code: Push
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe1, out label: 25600
Nexthop addr: 40.1.1.2 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 2.2.2.2/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe2, out label: 25604
Nexthop addr: 30.1.1.1 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 3.3.3.3/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 30.1.1.1 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 5.5.5.5/32, id: 1, row status: Active, Tunnel-Policy: N/A
```

```
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.1.1.2 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe1, out label: 25601
Nexthop addr: 40.1.1.2 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 10.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25605
Nexthop addr: 30.1.1.1 cross connect ix: 5, op code: Push
Primary FTN entry with FEC: 20.1.1.0/24, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 30.1.1.1 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 50.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 40.1.1.2 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25603
```

```
Nexthop addr: 40.1.1.2 cross connect ix: 8, op code: Push
 PE3#
P2#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
4.4.4.4 xe2 Active OPERATIONAL 30 01:56:09
6.6.6.6 xe1 Passive OPERATIONAL 30 01:55:26
P2#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
PE3 xe2 5254.0028.c36b Up 22 L1 IS-IS
PE4 xe1 5254.00d9.5db1 Up 7 L1 IS-IS
Check the ISIS route installation in the ISIS table and RIB table.
P2#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid
Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 30 50.1.1.2 xe1 0
L1 2.2.2.2/32 40 50.1.1.2 xe1 0
40.1.1.1 xe2 0
L1 3.3.3.3/32 30 40.1.1.1 xe2 0
L1 4.4.4.4/32 20 40.1.1.1 xe2 0
C 5.5.5.5/32 10 -- lo 0
L1 6.6.6.6/32 20 50.1.1.2 xe1 0
L1 10.1.1.0/24 30 50.1.1.2 xe1 0
L1 20.1.1.0/24 30 40.1.1.1 xe2 0
L1 30.1.1.0/24 20 40.1.1.1 xe2 0
C 40.1.1.0/24 10 -- xe2 0
C 50.1.1.0/24 10 -- xe1 0
L1 60.1.1.0/24 20 50.1.1.2 xe1 0
P2#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, eth0
i L1 1.1.1.1/32 [115/30] via 50.1.1.2, xe1, 01:58:18
i L1 2.2.2.2/32 [115/40] via 40.1.1.1, xe2, 01:58:18
[115/40] via 50.1.1.2, xe1
i L1 3.3.3.3/32 [115/30] via 40.1.1.1, xe2, 01:58:33
```

```
i L1 4.4.4.4/32 [115/20] via 40.1.1.1, xe2, 01:58:34
C 5.5.5.5/32 is directly connected, lo, 02:02:16
i L1 6.6.6.6/32 [115/20] via 50.1.1.2, xe1, 01:58:18
i L1 10.1.1.0/24 [115/30] via 50.1.1.2, xe1, 01:58:18
C 10.12.49.0/24 is directly connected, xe0, 02:06:21
i L1 20.1.1.0/24 [115/30] via 40.1.1.1, xe2, 01:58:33
i L1 30.1.1.0/24 [115/20] via 40.1.1.1, xe2, 01:58:34
C 40.1.1.0/24 is directly connected, xe2, 02:02:16
C 50.1.1.0/24 is directly connected, xe1, 02:02:16
i L1 60.1.1.0/24 [115/20] via 50.1.1.2, xe1, 01:58:18
C 127.0.0.0/8 is directly connected, lo, 02:15:41
P2#show ldp targeted-peers
IP Address Interface
4.4.4.4 xe2
6.6.6.6 xe1
Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify
the same in FTN table.
P2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 6 5 - Yes LSP_DEFAULT 25604 xe1 No 50.1.1.2
L> 2.2.2.2/32 5 4 - Yes LSP_DEFAULT 25604 xe2 No 40.1.1.1
6 - Yes LSP_DEFAULT 25605 xe1 No 50.1.1.2
L> 3.3.3.3/32 1 1 - Yes LSP_DEFAULT 25600 xe2 No 40.1.1.1
L> 4.4.4.4/32 2 2 - Yes LSP_DEFAULT 3 xe2 No 40.1.1.1
L> 6.6.6.6/32 7 7 - Yes LSP_DEFAULT 3 xe1 No 50.1.1.2
L> 10.1.1.0/24 8 8 - Yes LSP_DEFAULT 25606 xe1 No 50.1.1.2
L> 20.1.1.0/24 3 3 - Yes LSP_DEFAULT 25601 xe2 No 40.1.1.1
L> 30.1.1.0/24 4 2 - Yes LSP_DEFAULT 3 xe2 No 40.1.1.1
L> 60.1.1.0/24 9 7 - Yes LSP_DEFAULT 3 xe1 No 50.1.1.2
P2#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.1/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe1, out label: 25604
Nexthop addr: 50.1.1.2 cross connect ix: 6, op code: Push
Primary FTN entry with FEC: 2.2.2.2/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe2, out label: 25604
Nexthop addr: 40.1.1.1 cross connect ix: 4, op code: Push
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe1, out label: 25605
Nexthop addr: 50.1.1.2 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 3.3.3.3/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe2, out label: 25600
Nexthop addr: 40.1.1.1 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 4.4.4.4/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 40.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 6.6.6.6/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.1.1.2 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 10.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A

Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe1, out label: 25606
Nexthop addr: 50.1.1.2 cross connect ix: 8, op code: Push
Primary FTN entry with FEC: 20.1.1.0/24, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe2, out label: 25601
```

```
Nexthop addr: 40.1.1.1 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 30.1.1.0/24, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 40.1.1.1 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 60.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, BGP Color: 0, Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 50.1.1.2 cross connect ix: 7, op code: Push
PE4#show ldp session
Peer IP Address IF Name My Role State KeepAlive UpTime
5.5.5.5 xe2 Active OPERATIONAL 30 02:03:56
1.1.1.1 xe1 Active OPERATIONAL 30 02:04:24
PE4#show clns neighbors
Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag rlfa: VRF : default
System Id Interface SNPA State Holdtime Type Protocol
P2 xe2 5254.0043.7db3 Up 21 L1 IS-IS

PE1 xe1 5254.006e.5166 Up 19 L1 IS-IS
Verify ISIS LFA and RLFA backup computed paths for Primary Paths
PE4#show ip isis route
Codes: C - connected, E - external, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, D - discard, e - external metric
** - invalid
Tag rlfa: VRF : default
Destination Metric Next-Hop Interface Tag
L1 1.1.1.1/32 20 60.1.1.2 xe1 0
L1 2.2.2.2/32 30 60.1.1.2 xe1 0
L1 3.3.3.3/32 40 50.1.1.1 xe2 0
60.1.1.2 xe1 0
L1 4.4.4.4/32 30 50.1.1.1 xe2 0
L1 5.5.5.5/32 20 50.1.1.1 xe2 0
C 6.6.6.6/32 10 -- lo 0
L1 10.1.1.0/24 20 60.1.1.2 xe1 0
L1 20.1.1.0/24 30 60.1.1.2 xe1 0
L1 30.1.1.0/24 30 50.1.1.1 xe2 0
L1 40.1.1.0/24 20 50.1.1.1 xe2 0
C 50.1.1.0/24 10 -- xe2 0
```

```
C 60.1.1.0/24 10 -- xe1 0
PE4#show ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
ia - IS-IS inter area, E - EVPN,
v - vrf leaked
* - candidate default
IP Route Table for VRF "default"
Gateway of last resort is 10.12.49.1 to network 0.0.0.0
K* 0.0.0.0/0 [0/0] via 10.12.49.1, xe0
i L1 1.1.1.1/32 [115/20] via 60.1.1.2, xe1, 02:05:57
i L1 2.2.2.2/32 [115/30] via 60.1.1.2, xe1, 02:05:40
i L1 3.3.3.3/32 [115/40] via 60.1.1.2, xe1, 02:05:40
[115/40] via 50.1.1.1, xe2
i L1 4.4.4.4/32 [115/30] via 50.1.1.1, xe2, 02:05:40
i L1 5.5.5.5/32 [115/20] via 50.1.1.1, xe2, 02:05:40
C 6.6.6.6/32 is directly connected, lo, 02:09:10
i L1 10.1.1.0/24 [115/20] via 60.1.1.2, xe1, 02:05:57
C 10.12.49.0/24 is directly connected, xe0, 02:13:17
i L1 20.1.1.0/24 [115/30] via 60.1.1.2, xe1, 02:05:40
i L1 30.1.1.0/24 [115/30] via 50.1.1.1, xe2, 02:05:40
i L1 40.1.1.0/24 [115/20] via 50.1.1.1, xe2, 02:05:40
C 50.1.1.0/24 is directly connected, xe2, 02:09:10
C 60.1.1.0/24 is directly connected, xe1, 02:09:10
C 127.0.0.0/8 is directly connected, lo, 02:23:07
PE4#show ldp targeted-peers
IP Address Interface
1.1.1.1 xe1
5.5.5.5 xe2
Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify
the same in FTN table.
PE4#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
Code FEC FTN-ID Nhlfe-ID Tunnel-id Pri LSP-Type Out-Label Out-Intf ELC Nexthop
L> 1.1.1.1/32 1 1 - Yes LSP_DEFAULT 3 xe1 No 60.1.1.2
L> 2.2.2.2/32 3 2 - Yes LSP_DEFAULT 25604 xe1 No 60.1.1.2
L> 3.3.3.3/32 4 3 - Yes LSP_DEFAULT 25605 xe1 No 60.1.1.2
5 - Yes LSP_DEFAULT 25604 xe2 No 50.1.1.1
L> 4.4.4.4/32 6 6 - Yes LSP_DEFAULT 25605 xe2 No 50.1.1.1
L> 5.5.5.5/32 7 7 - Yes LSP_DEFAULT 3 xe2 No 50.1.1.1
L> 10.1.1.0/24 2 1 - Yes LSP_DEFAULT 3 xe1 No 60.1.1.2
L> 20.1.1.0/24 5 4 - Yes LSP_DEFAULT 25606 xe1 No 60.1.1.2
L> 30.1.1.0/24 8 8 - Yes LSP_DEFAULT 25607 xe2 No 50.1.1.1
L> 40.1.1.0/24 9 7 - Yes LSP_DEFAULT 3 xe2 No 50.1.1.1
PE4#show mpls ftn-table
```

```
Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 60.1.1.2 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 2.2.2.2/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: LDP, Stale: NO, out intf: xe1, out label: 25604
Nexthop addr: 60.1.1.2 cross connect ix: 2, op code: Push
Primary FTN entry with FEC: 3.3.3.3/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe1, out label: 25605
Nexthop addr: 60.1.1.2 cross connect ix: 3, op code: Push
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe2, out label: 25604
Nexthop addr: 50.1.1.1 cross connect ix: 3, op code: Push
Primary FTN entry with FEC: 4.4.4.4/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:92403, pkts:1494, TX bytes:98379, Pushed pkts:1494
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 6
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe2, out label: 25605
Nexthop addr: 50.1.1.1 cross connect ix: 6, op code: Push
Primary FTN entry with FEC: 5.5.5.5/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.1.1.1 cross connect ix: 7, op code: Push
Primary FTN entry with FEC: 10.1.1.0/24, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
```

```
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe1, out label: 3
Nexthop addr: 60.1.1.2 cross connect ix: 1, op code: Push
Primary FTN entry with FEC: 20.1.1.0/24, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 4
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe1, out label: 25606
Nexthop addr: 60.1.1.2 cross connect ix: 4, op code: Push
Primary FTN entry with FEC: 30.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 8
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe2, out label: 25607
Nexthop addr: 50.1.1.1 cross connect ix: 8, op code: Push
Primary FTN entry with FEC: 40.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 7
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 50.1.1.1 cross connect ix: 7, op code: Push
```

CHAPTER 7 LDP MD5 Password For Auto Targeted Sessions

A basic mechanism using Loop-Free Alternates (LFAs) is described in RFC5286 that provides good repair coverage in many topologies, especially those that are highly meshed.

However, some topologies, notably ring-based topologies, are not well protected by LFAs alone. This is because there is no neighbor of the Point of Local Repair (PLR) that has a cost to the destination via a path that does not traverse the failure that is cheaper than the cost to the destination via the failure.

When LDP RLFA creates a virtual path in the network to provide an alternate path, it uses MPLS labels distributed by a targeted session between the local node and the PLR (PQ node), the session is established without any MD5 Password protection mechanism, as it is only available for non-automatic targeted sessions. A set of configurable options will be provided to associate MD5 passwords to the auto-targeted sessions.

Topology

Figure 7-8 shows the configuration required to enable the RLFA feature.

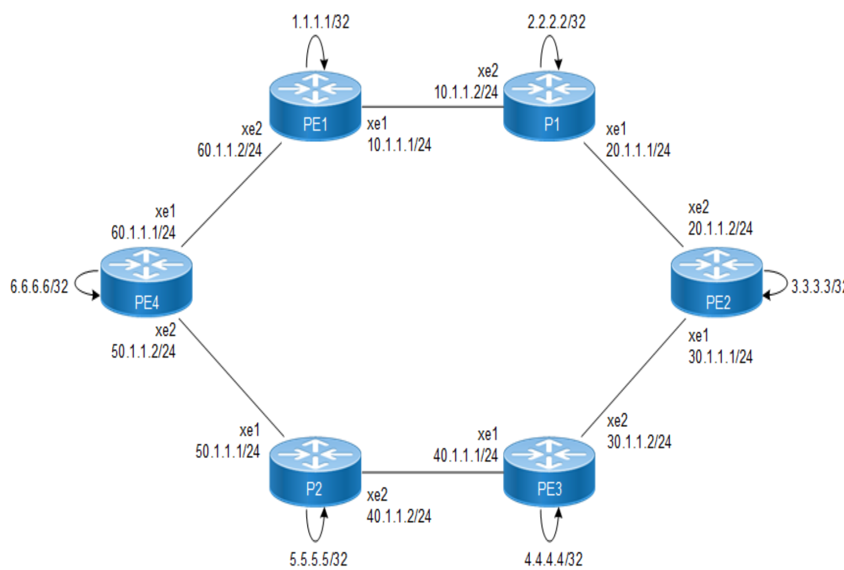

Figure 7-8: RLFA Topology

Configuration

RTR 1

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enable LDP process
`(config-router)#fast-reroute`	Enable LDP FRR
`(config-router)#auto-targeted-session`	To Allow creating TLDP session dynamically
`(config-router)#neighbor auto-targeted auth md5 password plain-text test2`	Configure md5 authentication for auto-targeted peers

(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 60.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 1.1.1.1/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 1.1.1.1	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# fast-reroute per-prefix remote-lfa area 0.0.0.0 tunnel mpls-ldp	. Configure Remote LFA to calculate backup paths to those destinations whichever does not satisfy basic LFA FRR inequalities
(config-router)# network 1.1.1.1/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes

(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#end	Exit router mode.
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally

RTR 2

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 2.2.2.2	Configure router id

(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 10.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 20.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

RTR 3

#configure terminal	Enter configure mode.
(config)#router ldp	Enable LDP process
(config-router)#fast-reroute	Enable LDP FRR
(config-router)#auto-targeted-session	To Allow creating TLDP session dynamically
(config-router)#neighbor auto-targeted auth md5 password plain-text test2	Configure md5 authentication for auto-targeted peers
(config-router)#commit	Commit the candidate configuration to the running configuration
(config-router)#exit	Exit LDP process
(config)#router rsvp	Enable RSPVP
(config-router)#srlg-disjoint forced	Configure srlg to enable mpls-TE
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 20.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 30.1.1.1/24	Configure the IP address of the interface.

`(config-if)#ip ospf cost 10`	Configure ospf cost
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#mpls traffic-eng srlg 11`	Enable mpls-TE
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe2 interface
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 3.3.3.3/32 secondary`	Configure the IP address of the interface
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Create an ospf instance
`(config-router)# ospf router-id 3.3.3.3`	Configure router id
`(config-router)# bfd all-interfaces`	Configure bfd
`(config-router)# timers spf exp 50 50`	Configure the ospf timers
`(config-router)# timers throttle lsa all 0 1 1`	Configure the ospf timer lsa throttle
`(config-router)# timers lsa arrival 1`	Configure the ospf timer lsa arrival
`(config-router)# network 3.3.3.3/32 area 0.0.0.0`	Configure the network command to advertise the prefixes
`(config-router)# network 20.1.1.0/24 area 0.0.0.0`	Configure the network command to advertise the prefixes
`(config-router)# network 30.1.1.0/24 area 0.0.0.0`	Configure the network command to advertise the prefixes
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config)# bfd interval 3 minrx 3 multiplier 3`	Configure bfd interval globally
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#end`	Exit router mode.

RTR 4

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enable LDP process
`(config-router)#fast-reroute`	Enable LDP FRR
`(config-router)#auto-targeted-session`	To Allow creating TLDP session dynamically
`(config-router)#neighbor auto-targeted auth md5 password plain-text test2`	Configure md5 authentication for auto-targeted peers
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit LDP process
`(config)#router rsvp`	Enable RSPVP
`(config-router)#srlg-disjoint forced`	Configure srlg to enable mpls-TE

(config-router)#commit	Commit the candidate configuration to the running configuration
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 30.1.1.2/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure the ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#enable-ldp ipv4	Enable ldp process on xe1 interface
(config-if)#mpls traffic-eng srlg 11	Enable Mpls-TE
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 40.1.1.1/24	Configure the IP address of the interface.
(config-if)#ip ospf cost 10	Configure ospf cost
(config-if)#label-switching	Enable label-switching on interface
(config-if)#mpls traffic-eng srlg 11	Enable mpls-TE
(config-if)#enable-ldp ipv4	Enable ldp process on xe2 interface
(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 4.4.4.4/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 4.4.4.4	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# network 4.4.4.4/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 40.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 30.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

RTR 5

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enable LDP process
`(config-router)#fast-reroute`	Enable LDP FRR
`(config-router)#auto-targeted-session`	To Allow creating TLDP session dynamically
`(config-router)#neighbor auto-targeted auth md5 password plain-text test2`	Configure md5 authentication for auto-targeted peers
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit LDP process
`(config)#router rsvp`	Enable RSPVP
`(config-router)#srlg-disjoint forced`	Configure srlg to enable mpls-TE
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 40.1.1.2/24`	Configure the IP address of the interface.
`(config-if)#ip ospf cost 10`	Configure the ospf cost
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe1 interface
`(config-if)#mpls traffic-eng srlg 11`	Enable Mpls-TE
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 50.1.1.1/24`	Configure the IP address of the interface.
`(config-if)#ip ospf cost 10`	Configure ospf cost
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#mpls traffic-eng srlg 11`	Enable mpls-TE
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe2 interface
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 5.5.5.5/32 secondary`	Configure the IP address of the interface
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf 1`	Create an ospf instance
`(config-router)# ospf router-id 5.5.5.5`	Configure router id
`(config-router)# bfd all-interfaces`	Configure bfd
`(config-router)# timers spf exp 50 50`	Configure the ospf timers
`(config-router)# timers throttle lsa all 0 1 1`	Configure the ospf timer lsa throttle
`(config-router)# timers lsa arrival 1`	Configure the ospf timer lsa arrival

`(config-router)# network 5.5.5.5/32 area 0.0.0.0`	Configure the network command to advertise the prefixes
`(config-router)# network 50.1.1.0/24 area 0.0.0.0`	Configure the network command to advertise the prefixes
`(config-router)# network 40.1.1.0/24 area 0.0.0.0`	Configure the network command to advertise the prefixes
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config)# bfd interval 3 minrx 3 multiplier 3`	Configure bfd interval globally
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#end`	Exit router mode.

RTR 6

`#configure terminal`	Enter configure mode.
`(config)#router ldp`	Enable LDP process
`(config-router)#fast-reroute`	Enable LDP FRR
`(config-router)#auto-targeted-session`	To Allow creating TLDP session dynamically
`(config-router)#neighbor auto-targeted auth md5 password plain-text test2`	Configure md5 authentication for auto-targeted peers
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config-router)#exit`	Exit LDP process
`(config)#router rsvp`	Enable RSPVP
`(config-router)#srlg-disjoint forced`	Configure srlg to enable mpls-TE
`(config-router)#commit`	Commit the candidate configuration to the running configuration
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 50.1.1.2/24`	Configure the IP address of the interface.
`(config-if)#ip ospf cost 10`	Configure the ospf cost
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe1 interface
`(config-if)#mpls traffic-eng srlg 11`	Enable Mpls-TE
`(config-if)#commit`	Commit the candidate configuration to the running configuration
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 60.1.1.2/24`	Configure the IP address of the interface.
`(config-if)#ip ospf cost 10`	Configure ospf cost
`(config-if)#label-switching`	Enable label-switching on interface
`(config-if)#mpls traffic-eng srlg 11`	Enable mpls-TE
`(config-if)#enable-ldp ipv4`	Enable ldp process on xe2 interface

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(config-if)#commit	Commit the candidate configuration to the running configuration
(config-if)#exit	Exit interface mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 6.6.6.6/32 secondary	Configure the IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Create an ospf instance
(config-router)# ospf router-id 6.6.6.6	Configure router id
(config-router)# bfd all-interfaces	Configure bfd
(config-router)# timers spf exp 50 50	Configure the ospf timers
(config-router)# timers throttle lsa all 0 1 1	Configure the ospf timer lsa throttle
(config-router)# timers lsa arrival 1	Configure the ospf timer lsa arrival
(config-router)# network 6.6.6.6/32 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 50.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)# network 60.1.1.0/24 area 0.0.0.0	Configure the network command to advertise the prefixes
(config-router)#commit	Commit the candidate configuration to the running configuration
(config)# bfd interval 3 minrx 3 multiplier 3	Configure bfd interval globally
(config)#commit	Commit the candidate configuration to the running configuration
(config)#end	Exit router mode.

Validation

RTR 1

Check LDP neighborship before enabling RLFA

```
Rtr1#sh ldp session
Peer IP Address            IF Name    My Role    State       KeepAlive  UpTime
2.2.2.2                    xe20       Passive   OPERATIONAL   30    00:02:43
6.6.6.6                    ge10       Passive   OPERATIONAL   30    00:00:30
```

Check the output of "show ip ospf neighbors" to verify that ospf adjacency is up.

Rtr1#sh ip ospf neighbor

```
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
       Instance ID
2.2.2.2           1   Full/Backup      00:00:39    10.1.1.2        xe20
           0
```

```
6.6.6.6           1   Full/DR          00:00:35    60.1.1.2        ge10
           0
Rtr1#
Check the ospf route installation in the ospf table and RIB table.
Rtr1#sh ip route
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2,
       ia - IS-IS inter area, E - EVPN,
       v - vrf leaked
       * - candidate default

IP Route Table for VRF "default"
C            1.1.1.1/32 is directly connected, lo, 00:37:05
O            2.2.2.2/32 [110/11] via 10.1.1.2, xe20, 00:04:49
O            3.3.3.3/32 [110/21] via 10.1.1.2, xe20, 00:04:49
O            4.4.4.4/32 [110/31] via 60.1.1.2, ge10, 00:04:49
                        [110/31] via 10.1.1.2, xe20
O            5.5.5.5/32 [110/21] via 60.1.1.2, ge10, 00:02:29
O            6.6.6.6/32 [110/11] via 60.1.1.2, ge10, 00:02:29
C            10.1.1.0/24 is directly connected, xe20, 00:33:59
O            20.1.1.0/24 [110/20] via 10.1.1.2, xe20, 00:04:49
O            30.1.1.0/24 [110/30] via 10.1.1.2, xe20, 00:04:49
O            40.1.1.0/24 [110/30] via 60.1.1.2, ge10, 00:02:29
O            50.1.1.0/24 [110/20] via 60.1.1.2, ge10, 00:02:29
C            60.1.1.0/24 is directly connected, ge10, 00:02:36
C            127.0.0.0/8 is directly connected, lo, 00:45:19

Gateway of last resort is not set
Rtr1#
Rtr1#sh ip ospf route

OSPF process 1:
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       OSPF LFA attributes:
       P - Primary, SP - Secondary-Path, LP - Link Protecting,
       NP - Node Protecting, BID - Broadcast Link Protecting
       DP - Downstream Protecting

C  1.1.1.1/32 [1] is directly connected, lo, Area 0.0.0.0
O  2.2.2.2/32 [11] via 10.1.1.2, xe20, Area 0.0.0.0
O  3.3.3.3/32 [21] via 10.1.1.2, xe20, Area 0.0.0.0
O  4.4.4.4/32 [31] via 10.1.1.2, xe20, Area 0.0.0.0
                   via 60.1.1.2, ge10, Area 0.0.0.0
O  5.5.5.5/32 [21] via 60.1.1.2, ge10, Area 0.0.0.0
O  6.6.6.6/32 [11] via 60.1.1.2, ge10, Area 0.0.0.0
```

```
C  10.1.1.0/24 [10] is directly connected, xe20, Area 0.0.0.0
O  20.1.1.0/24 [20] via 10.1.1.2, xe20, Area 0.0.0.0
O  30.1.1.0/24 [30] via 10.1.1.2, xe20, Area 0.0.0.0
O  40.1.1.0/24 [30] via 60.1.1.2, ge10, Area 0.0.0.0
O  50.1.1.0/24 [20] via 60.1.1.2, ge10, Area 0.0.0.0
C  60.1.1.0/24 [10] is directly connected, ge10, Area 0.0.0.0
Rtr1#
```

Verify ospf LFA and RLFA backup computed paths for Primary Paths

```
Rtr1#sh ip ospf route fast-reroute

OSPF process 1:
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       OSPF LFA attributes:
       P - Primary, SP - Secondary-Path, LP - Link Protecting,
       NP - Node Protecting, BID - Broadcast Link Protecting
       DP - Downstream Protecting

O  2.2.2.2/32 [11] via 10.1.1.2, xe20, Area 0.0.0.0
                        Remote FRR path:
                        via 4.4.4.4, via 60.1.1.2, ge10, Area 0.0.0.0
                       Attributes: Metric: [51] ,LP
O  3.3.3.3/32 [21] via 10.1.1.2, xe20, Area 0.0.0.0
                        Remote FRR path:
                        via 4.4.4.4, via 60.1.1.2, ge10, Area 0.0.0.0
                       Attributes: Metric: [41] ,LP ,NP ,DP
O  4.4.4.4/32 [31] via 10.1.1.2, xe20, Area 0.0.0.0
                        Backup path:
                         via 60.1.1.2, ge10, Area 0.0.0.0
                        Attributes: Metric: [31] ,P ,NP ,BID ,DP
                   via 60.1.1.2, ge10, Area 0.0.0.0
                        Backup path:
                         via 10.1.1.2, xe20, Area 0.0.0.0
                        Attributes: Metric: [31] ,P ,NP ,BID ,DP
O  5.5.5.5/32 [21] via 60.1.1.2, ge10, Area 0.0.0.0
                        Remote FRR path:
                        via 4.4.4.4, via 10.1.1.2, xe20, Area 0.0.0.0
                       Attributes: Metric: [41] ,LP ,NP ,DP
O  6.6.6.6/32 [11] via 60.1.1.2, ge10, Area 0.0.0.0
                        Remote FRR path:
                        via 4.4.4.4, via 10.1.1.2, xe20, Area 0.0.0.0
                       Attributes: Metric: [51] ,LP
O  20.1.1.0/24 [20] via 10.1.1.2, xe20, Area 0.0.0.0
                        Remote FRR path:
                         via 4.4.4.4, via 60.1.1.2, ge10, Area 0.0.0.0
                        Attributes: Metric: [50] ,LP ,NP
O  30.1.1.0/24 [30] via 10.1.1.2, xe20, Area 0.0.0.0
                        Backup path:
```

```
                          via 60.1.1.2, ge10, Area 0.0.0.0
                         Attributes: Metric: [40] ,SP ,NP ,BID
O  40.1.1.0/24 [30] via 60.1.1.2, ge10, Area 0.0.0.0
                        Backup path:
                          via 10.1.1.2, xe20, Area 0.0.0.0
                         Attributes: Metric: [40] ,SP ,NP ,BID
O  50.1.1.0/24 [20] via 60.1.1.2, ge10, Area 0.0.0.0
                        Remote FRR path:
                         via 4.4.4.4, via 10.1.1.2, xe20, Area 0.0.0.0
                        Attributes: Metric: [50] ,LP ,NP
Rtr1#
```

Verify PQ node which is near to source is selected and Target-LDP session is established with PQ node using below commands

```
Rtr1#sh ldp session
Peer IP Address           IF Name    My Role    State       KeepAlive  UpTime
2.2.2.2                   xe20       Passive   OPERATIONAL   30    00:07:29
6.6.6.6                   ge10       Passive   OPERATIONAL   30    00:05:16
4.4.4.4                   xe20       Passive   OPERATIONAL   30    00:05:04

To verify which password is enabled
Rtr1#sh ldp session 4.4.4.4
Session state         : OPERATIONAL
Session role          : Passive
TCP Connection        : Established
IP Address for TCP    : 4.4.4.4
Interface being used  : xe23
Peer LDP ID           : 4.4.4.4:0
Peer LDP Password     : test2
Authentication type   : MD5
Adjacencies           : 4.4.4.4
Advertisement mode    : Downstream Unsolicited
Label retention mode  : Liberal
Graceful Restart      : Not Capable
Keepalive Timeout     : 30
Reconnect Interval    : 15
Address List received : 4.4.4.4
                        40.1.1.2
                        70.1.1.2
Received Labels :       Fec              Label           Maps To
                IPV4:70.1.1.0/24       impl-null       none
                IPV4:60.1.1.0/24       35218           none
                IPV4:50.1.1.0/24       35216           none
                IPV4:40.1.1.0/24       impl-null       none
                IPV4:20.1.1.0/24       35214           none
                IPV4:10.1.1.0/24       35212           none
                IPV4:6.6.6.6/32        35209           none
                IPV4:5.5.5.5/32        35207           none
                IPV4:4.4.4.4/32        impl-null       none
```

```
                IPV4:3.3.3.3/32         35205           none
                IPV4:2.2.2.2/32         35203           none
                IPV4:1.1.1.1/32         35202           none
Sent Labels :   Fec                     Label           Maps To
                IPV4:70.1.1.0/24        35218           34563
                IPV4:70.1.1.0/24        35218           34567
                IPV4:60.1.1.0/24        35217           34564
                IPV4:60.1.1.0/24        35217           34562
                IPV4:50.1.1.0/24        impl-null       none
                IPV4:40.1.1.0/24        35216           impl-null
                IPV4:20.1.1.0/24        35215           impl-null
                IPV4:10.1.1.0/24        impl-null       none
                IPV4:6.6.6.6/32         35214           34565
                IPV4:6.6.6.6/32         35214           34561
                IPV4:5.5.5.5/32         35213           impl-null
                IPV4:4.4.4.4/32         35212           34560
                IPV4:3.3.3.3/32         35211           34561
                IPV4:2.2.2.2/32         35210           impl-null
                IPV4:1.1.1.1/32         impl-null       none
```

Verify that Primary and Backup FTN's are installed with labels in LDP RLFA route table

Rtr1#sh ldp rlfa-routes

```
Codes: p - stale rLFA route
Fec             Primary-NH      Backup-NH       rLFA-Addr       Out-Intf  Outer-label
Inner-label Owner

2.2.2.2       10.1.1.2      60.1.1.2      4.4.4.4       ge10     24964      24969
ospf
3.3.3.3       10.1.1.2      60.1.1.2      4.4.4.4       ge10     24964      24970
ospf
5.5.5.5       60.1.1.2      10.1.1.2      4.4.4.4       xe20     24963      24971
ospf
6.6.6.6       60.1.1.2      10.1.1.2      4.4.4.4       xe20     24963      24972
ospf
20.1.1.0      10.1.1.2      60.1.1.2      4.4.4.4       ge10     24964      24974
ospf
50.1.1.0      60.1.1.2      10.1.1.2      4.4.4.4       xe20     24963      24975
ospf
```

Verify that backup XC's calculated for primary FTN's in MPLS forwarding table. Verify the same in FTN table.

```
Rtr1#sh mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
```

```
   L>   2.2.2.2/32         1        2        -          Yes   LSP_DEFAULT  3
xe20        No    10.1.1.2
                                    23       -          No    LSP_DEFAULT  24969
ge10        No    4.4.4.4
                                                                                (via
60.1.1.2 ,label 24964)
   L>   3.3.3.3/32         2        4        -          Yes   LSP_DEFAULT  24962
xe20        No    10.1.1.2
                                    24       -          No    LSP_DEFAULT  24970
ge10        No    4.4.4.4
                                                                                (via
60.1.1.2 ,label 24964)
   L>   4.4.4.4/32         3        6        -          Yes   LSP_DEFAULT  24963
xe20        No    10.1.1.2
                                    7        -          No    LSP_DEFAULT  24964
ge10        No    60.1.1.2
                                    7        -          Yes   LSP_DEFAULT  24964
ge10        No    60.1.1.2
                                    5        -          No    LSP_DEFAULT  24963
xe20        No    10.1.1.2
   L>   5.5.5.5/32         4        10       -          Yes   LSP_DEFAULT  24965
ge10        No    60.1.1.2
                                    25       -          No    LSP_DEFAULT  24971
xe20        No    4.4.4.4
                                                                                (via
10.1.1.2 ,label 24963)
   L>   6.6.6.6/32         5        15       -          Yes   LSP_DEFAULT  3
ge10        No    60.1.1.2
                                    26       -          No    LSP_DEFAULT  24972
xe20        No    4.4.4.4
                                                                                (via
10.1.1.2 ,label 24963)
   L>   20.1.1.0/24        6        11       -          Yes   LSP_DEFAULT  3
xe20        No    10.1.1.2
                                    27       -          No    LSP_DEFAULT  24974
ge10        No    4.4.4.4
                                                                                (via
60.1.1.2 ,label 24964)
   L>   30.1.1.0/24        7        13       -          Yes   LSP_DEFAULT  24966
xe20        No    10.1.1.2
                                    16       -          No    LSP_DEFAULT  24966
ge10        No    60.1.1.2
   L>   40.1.1.0/24        8        19       -          Yes   LSP_DEFAULT  24967
ge10        No    60.1.1.2
                                    20       -          No    LSP_DEFAULT  24967
xe20        No    10.1.1.2
   L>   50.1.1.0/24        9        22       -          Yes   LSP_DEFAULT  3
ge10        No    60.1.1.2
                                    28       -          No    LSP_DEFAULT  24975
xe20        No    4.4.4.4
                                                                                (via
10.1.1.2 ,label 24963)
Rtr1#sh mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
```

```
      Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
       Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe20, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 1, op code: Push

      Backup Cross connect ix: 9, in intf: - in label: 0  out-segment ix: 23
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 23, owner: LDP, Stale: NO, out intf: ge10, out label: 24969
    Nexthop addr: 4.4.4.4        cross connect ix: 9, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
      Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe20, out label: 24962
    Nexthop addr: 10.1.1.2        cross connect ix: 2, op code: Push

      Backup Cross connect ix: 11, in intf: - in label: 0  out-segment ix: 24
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 24, owner: LDP, Stale: NO, out intf: ge10, out label: 24970
    Nexthop addr: 4.4.4.4        cross connect ix: 11, op code: Push


 Primary FTN entry with FEC: 4.4.4.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
      Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe20, out label: 24963
    Nexthop addr: 10.1.1.2        cross connect ix: 3, op code: Push

      Backup Cross connect ix: 2, in intf: - in label: 0  out-segment ix: 7
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: ge10, out label: 24964
    Nexthop addr: 60.1.1.2        cross connect ix: 3, op code: Push

      Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 7
       Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
        Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: ge10, out label: 24964
    Nexthop addr: 60.1.1.2        cross connect ix: 3, op code: Push

      Backup Cross connect ix: 1, in intf: - in label: 0  out-segment ix: 5
       Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
        Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe20, out label: 24963
    Nexthop addr: 10.1.1.2        cross connect ix: 3, op code: Push
```

```
 Primary FTN entry with FEC: 5.5.5.5/32, id: 4, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 9
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: ge10, out label: 24965
    Nexthop addr: 60.1.1.2        cross connect ix: 5, op code: Push

     Backup Cross connect ix: 13, in intf: - in label: 0  out-segment ix: 25
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 25, owner: LDP, Stale: NO, out intf: xe20, out label: 24971
    Nexthop addr: 4.4.4.4        cross connect ix: 13, op code: Push


 Primary FTN entry with FEC: 6.6.6.6/32, id: 5, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 14
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 14, owner: N/A, Stale: NO, out intf: ge10, out label: 3
    Nexthop addr: 60.1.1.2        cross connect ix: 7, op code: Push

     Backup Cross connect ix: 15, in intf: - in label: 0  out-segment ix: 26
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 26, owner: LDP, Stale: NO, out intf: xe20, out label: 24972
    Nexthop addr: 4.4.4.4        cross connect ix: 15, op code: Push


 Primary FTN entry with FEC: 20.1.1.0/24, id: 6, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: xe20, out label: 3
    Nexthop addr: 10.1.1.2        cross connect ix: 1, op code: Push

     Backup Cross connect ix: 17, in intf: - in label: 0  out-segment ix: 27
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 27, owner: LDP, Stale: NO, out intf: ge10, out label: 24974
    Nexthop addr: 4.4.4.4        cross connect ix: 17, op code: Push


 Primary FTN entry with FEC: 30.1.1.0/24, id: 7, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 12
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
```

```
       Out-segment with ix: 12, owner: LDP, Stale: NO, out intf: xe20, out label: 24966
    Nexthop addr: 10.1.1.2        cross connect ix: 6, op code: Push

      Backup Cross connect ix: 3, in intf: - in label: 0  out-segment ix: 16
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 16, owner: LDP, Stale: NO, out intf: ge10, out label: 24966
    Nexthop addr: 60.1.1.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 40.1.1.0/24, id: 8, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
      Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 18
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 18, owner: LDP, Stale: NO, out intf: ge10, out label: 24967
    Nexthop addr: 60.1.1.2        cross connect ix: 8, op code: Push

      Backup Cross connect ix: 4, in intf: - in label: 0  out-segment ix: 20
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 20, owner: LDP, Stale: NO, out intf: xe20, out label: 24967
    Nexthop addr: 10.1.1.2        cross connect ix: 4, op code: Push


 Primary FTN entry with FEC: 50.1.1.0/24, id: 9, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: 
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
      Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 14
       Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 14, owner: N/A, Stale: NO, out intf: ge10, out label: 3
    Nexthop addr: 60.1.1.2        cross connect ix: 7, op code: Push

      Backup Cross connect ix: 19, in intf: - in label: 0  out-segment ix: 28
       Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
        Out-segment with ix: 28, owner: LDP, Stale: NO, out intf: xe20, out label: 24975
    Nexthop addr: 4.4.4.4        cross connect ix: 19, op code: Push


Rtr1#
```

Note: The following CLI will be used to configure different types of MD5 authentication.

- To configure dedicated MD5 password to a neighbor (under router ldp):
  `neighbor A.B.C.D auth md5 password (plain-text|encrypt) WORD`
  The same should be configured on neighbour A.B.C.D.
- To set password for all LDP neighbors (under router ldp):
  `neighbor all auth md5 password (plain-text|encrypt) WORD`
- To exclude password for a neighbor (under router ldp)
  `neighbor A.B.C.D auth md5 password exclude`

- To set password for auto-targeted sessions (under router ldp):
```
neighbor auto-targeted auth md5 password (plain-text|encrypt) WORD
```
- To create session group (under router ldp)
```
session-group name WORD
```
- To set password for the session group (under session group)
```
auth md5 password (plain-text|encrypt) WORD
```
- To add neighbors in the group (under session group)
```
neighbor prefix-list <prefix-list-name>
```

CHAPTER 8 LDP ECMP Configuration

This chapter contains configurations of LDP ECMP detailed tests that are used to verify the functionality of LDP ECMP (Equal-cost multipath).

Topology

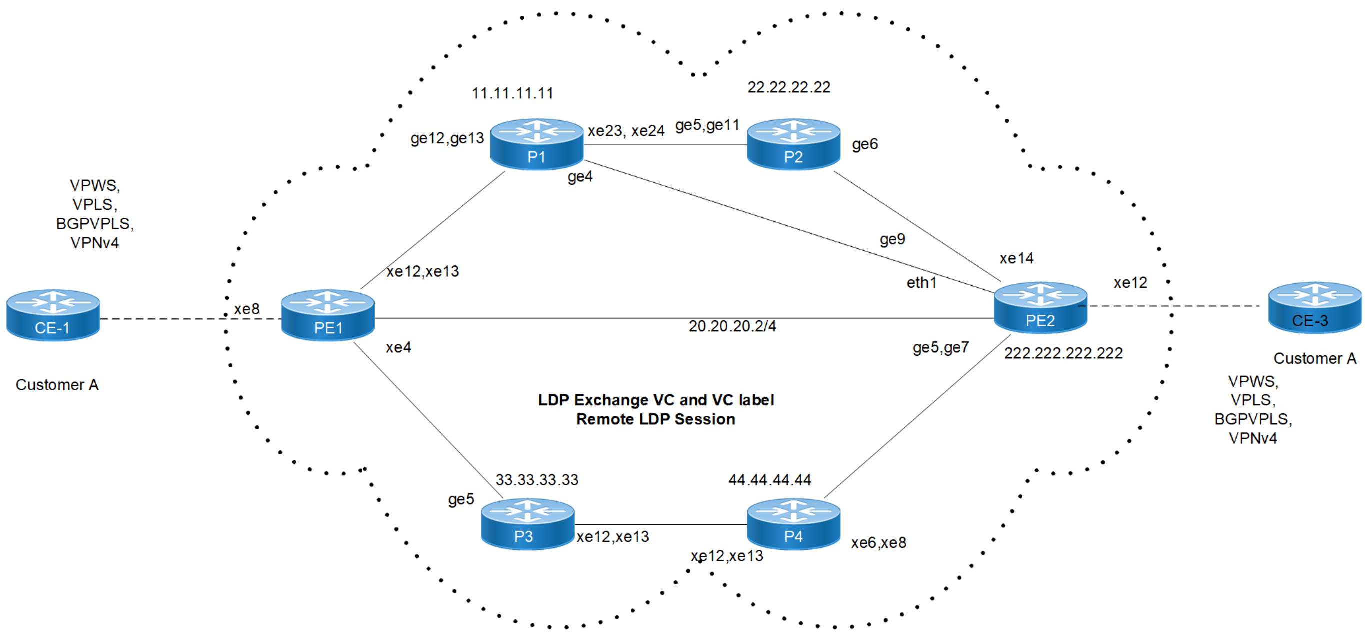

Figure 8-9: LDP-ECMP configuration topology

Configurations

PE-1

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 111.111.111.111/32 secondary`	Configure IP address for the loopback interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 111.111.111.111`	Configure Router-id
`(config-router)#targeted-peer ipv4 222.222.222.222`	Configuring targeted LDP sessions to PE-2

`(config-router)#explicit-null`	Configure explicit-null.
`(config-router)#entropy-label-capability`	Enable entropy capability in ldp
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit from targeted-peer mode
`(config-router)#transport-address ipv4 111.111.111.111`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#interface xe13`	Enter interface mode
`(config-if)#speed 1g`	Configure interface speed to 1g
`(config-if)#ip address 10.0.1.10/24`	Configure IP address on interface
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#interface po1000`	Enter the Interface mode for po1000
`(config-if)#exit`	Exit interface mode
`(config)#interface po1000.1000`	Enter interface mode for po1000.1000
`(config-if)#encapsulation dot1q 1000`	Configure encapsulation under a subinterface
`(config-if)#ip address 10.0.0.10/24`	Configure IP address on interface
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#interface xe4`	Enter interface mode
`(config-if)#speed 1g`	Configure interface speed to 1g
`(config-if)#ip address 16.0.0.10/24`	Configure IP address on interface
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#interface xe4.1001`	Enter interface mode
`(config-if)#encapsulation dot1q 1001`	Configure encapsulation under a subinterface
`(config-if)#ip address 16.0.1.10/24`	Configure IP address on interface
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration

(config-if)#exit	Exit interface mode
(config-if)#interface xe12	Enter interface mode
(config-if)#speed 1g	Configure interface speed to 1g
(config-if)#channel-group 1000 mode active	Moving interface to Dynamic LAG
(config-if)#exit	Exit interface mode
(config)#ip vrf l3vpnvrf300	IP VRF config with name l3vpnvrf300
(config-vrf)#rd 300:1	Route-distinguisher value
(config-vrf)#route-target both 300:1	Route target value
(config-vrf)#exit	Exit to config mode
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 111.111.111.111	Configure ospf Router-id
(config-router)#network 10.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 16.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 16.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 111.111.111.111/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#commit	Commit the transaction.
(config-router)#exit	Exit from router mode
(config)#router bgp 100	Configure router bgp in AS 100
(config-router)#bgp router-id 111.111.111.111	Configure BGP router ID
(config-router)#neighbor 222.222.222.222 remote-as 100	Configure neighbor in remote-as 100
(config-router)#neighbor 222.222.222.222 update-source lo	Configure neighbor with update-source loopback
(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
(config-router-af)#neighbor 222.222.222.222 activate	mode Activate VPNv4 neighbor
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#address-family l2vpn vpls	Enter vpls Address family mode
(config-router-af)#neighbor 222.222.222.222 activate	mode Activate vpls neighbor
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#address-family vrf l3vpnvrf300	Configure VRF address family
(config-router-af)#redistribute connected	Redistribute connected addresses
(config-router-af)#exit-address-family	Exit from Address Family configuration
(config-router)#exit	Exit from router mode

(config)#mpls vplsldp100 100	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling ldp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)# vpls-peer 222.222.222.222	Configuring VPLS mesh peers
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config)#mpls l2-circuit VPWS400 400 222.222.222.222	Configuring VPWS instance with name and VPWS ID
(config)#mpls vpls vplsbgp200 200	Configuring VPLS instance with name and VPLS ID
(config-vpls)#signaling bgp	Enabling LDP signaling for the VPLS instance
(config-vpls-sig)#ve-id 200	Configure VE ID, which is mandatory for BGP VPLS,
otherwise, signaling does not take place. VE ID should be	
unique per VPLS instance	
(config-vpls-sig)#exit-signaling	Exit from VPLS signaling mode
(config-vpls)#exit-vpls	Exit from VPLS mode
(config-if)#interface xe8.100 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vplsldp100	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#exit	Exit from access mode
(config-if)#interface xe8.400 switchport	Enter sub interface mode
(config-if)#encapsulation dot1q 400	Configure encapsulation under a subinterface
(config-if)#access-if-vpws	Access VPWS under sub interface
(config-acc-if-vpws)#mpls-vpws VPWS400	Associating the VPWS Instance to the attachment circuit interface.
(config-acc-if-vpws)#exit	Exit from access mode
(config-if)#interface xe8.200 switchport	Enter sub interface mode
(config-if)#split-horizon group access1	Configure split-horizon group on sub-interface
(config-if)#split-horizon group access1	Configure split-horizon group on sub-interface
(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#access-if-vpls	Access VPLS under sub interface
(config-acc-if-vpls)#mpls-vpls vplsbgp200	Associating the VPLS Instance to the attachment circuit interface.
(config-acc-if-vpls)#exit	Exit from access mode
(config-if)#interface xe8.300	Enter sub interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#ip vrf forwarding l3vpnvrf300	Attaching xe8.300 to as part of l3vpnvrf300
(config-if)#ip address 110.110.110.1/24	Configure the IP address of the interface.
(config-if)#exit	Exit interface mode
(config)#commit	Commit the configuration
(config)#end	Return to privilege mode

P1

`#configure terminal`	Enter Configure mode.
`(config)#mpls ilm-ecmp`	Enable ilm ecmp
`(config)#interface lo`	Enter interface mode
`(config -if)#ip address 11.11.11.11/32 secondary`	Configure IP address for the loopback interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#router ldp`	Enter router mode for LDP
`(config-router)#router-id 11.11.11.11`	Configure Router-id
`(config-router)#transport-address ipv4 11.11.11.11`	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
`(config-router)#commit`	Commit the configuration
`(config-router)#exit`	Exit from router mode
`(config)#interface ge13`	Enter interface mode
`(config-if)#ip address 10.0.1.20/24`	Configure IP address on interface
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#interface po1000`	Enter the Interface mode for po1000
`(config-if)#exit`	Exit interface mode
`(config)#interface po1000.1000`	Enter interface mode for po1000.1000
`(config-if)#encapsulation dot1q 1000`	Configure encapsulation under a subinterface
`(config-if)#ip address 10.0.0.20/24`	Configure IP address on interface
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface
`(config-if)#commit`	Commit the configuration
`(config-if)#exit`	Exit interface mode
`(config)#interface po2000`	Enter the Interface mode for po2000
`(config-if)#exit`	Exit interface mode
`(config)#interface po2000.100`	Enter interface mode for po2000.100
`(config-if)#encapsulation dot1q 100`	Configure encapsulation under a subinterface
`(config-if)#ip address 11.0.0.10/24`	Configure IP address on interface
`(config-if)#ip ospf cost 10`	Assign ospf cost to the interface
`(config-if)#label-switching`	Enable label switching capability on the interface
`(config-if)#enable-ldp ipv4`	Enabling LDP on the interface

(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge4	Enter interface mode
(config-if)#ip address 9.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 20	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge12	Enter interface mode
(config-if)#channel-group 1000 mode active	Moving interface to Dynamic LAG
(config)#interface xe23	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config-if)#speed 1g	Configure speed 1g
(config)#interface xe24	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config-if)#speed 1g	Configure speed 1g
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 11.11.11.11	Configure ospf Router-id
(config-router)#network 10.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 10.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 11.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 9.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 11.11.11.11/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

P2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 22.22.22.22/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode

(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 22.22.22.22	Configure Router-id
(config-router)#transport-address ipv4 22.22.22.22	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface ge6.300	Enter interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge6.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.1.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface po2000	Enter the Interface mode for po2000
(config-if)#exit	Exit interface mode
(config)#interface po2000.100	Enter interface mode for po2000.100
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#ip address 11.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge5	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config)#interface ge11	Enter interface mode
(config-if)#channel-group 2000 mode active	Moving interface to Dynamic LAG
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 22.22.22.22	Configure ospf Router-id

(config-router)#network 15.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 15.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 11.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 22.22.22.22/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

P3

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 33.33.33.33/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 33.33.33.33	Configure Router-id
(config-router)#transport-address ipv4 33.33.33.33	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface ge5	Enter interface mode
(config-if)#ip address 16.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface ge5.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 16.0.1.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa4000	Enter the Interface mode for sa4000
(config-if)#exit	Exit interface mode
(config)#interface sa4000.200	Enter interface mode for psa4000.200

(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#ip address 17.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe12	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config)#interface xe13	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 33.33.33.33	Configure ospf Router-id
(config-router)#network 16.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 16.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 17.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 33.33.33.33/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

P4

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 44.44.44.44/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 44.44.44.44	Configure Router-id
(config-router)#transport-address ipv4 44.44.44.44	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface sa3000	Enter the Interface mode for sa3000
(config-if)#exit	Exit interface mode

(config)#interface sa3000	Enter interface mode
(config-if)#ip address 18.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa3000.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 18.0.1.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa4000	Enter the Interface mode for sa4000
(config-if)#exit	Exit interface mode
(config)#interface sa4000.200	Enter interface mode for psa4000.200
(config-if)#encapsulation dot1q 200	Configure encapsulation under a subinterface
(config-if)#ip address 17.0.0.10/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe6	Enter interface mode
config-if)#speed 1g	Configure speed 1g
(config-if)#static-channel-group 3000	Moving interface to Static LAG
(config)#interface xe8	Enter interface mode
config-if)#speed 1g	Configure speed 1g
(config-if)#static-channel-group 3000	Moving interface to Static LAG
(config)#interface xe12	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config)#interface xe13	Enter interface mode
(config-if)# static-channel-group 4000	Moving interface to Static LAG
(config-if)#exit	Exit interface mode
(config)#commit	Commit the transaction.
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 44.44.44.44	Configure ospf Router-id

(config-router)#network 18.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 18.0.1.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 17.0.0.0/24 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#network 44.44.44.44/32 area 0	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
(config-router)#exit	Exit from router mode
(config)#commit	Commit the transaction.

PE2

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config -if)#ip address 222.222.222.222/32 secondary	Configure IP address for the loopback interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#router ldp	Enter router mode for LDP
(config-router)#router-id 222.222.222.222	Configure Router-id
(config-router)#targeted-peer ipv4 111.111.111.111	Configuring targeted LDP sessions to PE-2
(config-router)#explicit-null	Configure explicit-null.
(config-router)#entropy-label-capability	Enable entropy capability in ldp
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit from targeted-peer mode
(config-router)#transport-address ipv4 222.222.222.222	Configure the transport address to be used for a TCP session over which LDP will run on an IPv4 interface
(config-router)#commit	Commit the configuration
(config-router)#exit	Exit from router mode
(config)#interface xe14	Enter interface mode
(config-if)#speed 1g	Configure interface speed to 1g
(config)#interface xe14.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.1.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface xe14.1002	Enter interface mode
(config-if)#encapsulation dot1q 300	Configure encapsulation under a subinterface
(config-if)#ip address 15.0.0.20/24	Configure IP address on interface

(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa3000	Enter interface mode
(config-if)#ip address 18.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#interface sa3000.1001	Enter interface mode
(config-if)#encapsulation dot1q 1001	Configure encapsulation under a subinterface
(config-if)#ip address 18.0.1.20/24	Configure IP address on interface
(config-if)#ip ospf cost 10	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config-if)#interface ge5	Enter interface mode
(config-if)# static-channel-group 3000	Moving interface to static LAG
(config-if)#interface ge7	Enter interface mode
(config-if)# static-channel-group 3000	Moving interface to static LAG
(config-if)#exit	Exit interface mode
(config)#interface ge9	Enter interface mode
(config-if)#ip address 9.0.0.20/24	Configure IP address on interface
(config-if)#ip ospf cost 20	Assign ospf cost to the interface
(config-if)#label-switching	Enable label switching capability on the interface
(config-if)#enable-ldp ipv4	Enabling LDP on the interface
(config-if)#commit	Commit the configuration
(config-if)#exit	Exit interface mode
(config)#ip vrf l3vpnvrf300	IP VRF config with name l3vpnvrf300
(config-vrf)#rd 300:1	Route-distinguisher value
(config-vrf)#route-target both 300:1	Route target value
(config-vrf)#exit	Exit to config mode
(config)#router ospf 100	Configure the routing process and specify the Process ID, (100). The Process ID should be a unique positive integer to identifying the routing process.
(config-router)#ospf router-id 222.222.222.222	Configure ospf Router-id

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`(config-router)#network 9.0.0.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 15.0.0.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 15.0.1.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 18.0.0.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 18.0.1.0/24 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#network 222.222.222.222/32 area 0`	Define the interface on which OSPF runs and associate the area ID (0) with the interface.
`(config-router)#commit`	Commit the transaction.
`(config-router)#exit`	Exit from router mode
`(config)#router bgp 100`	Configure router bgp in AS 100
`(config-router)#bgp router-id 222.222.222.222`	Configure BGP router ID
`(config-router)#neighbor 111.111.111.111 remote-as 100`	Configure neighbor in remote-as 100
`(config-router)#neighbor 111.111.111.111 update-source lo`	Configure neighbor with update-source loopback
`(config-router)#address-family vpnv4 unicast`	Enter VPNv4 Address family mode
`(config-router-af)#neighbor 111.111.111.111 activate`	mode Activate VPNv4 neighbor
`(config-router-af)#exit-address-family`	Exit from Address Family configuration
`(config-router)#address-family l2vpn vpls`	Enter vpls Address family mode
`(config-router-af)#neighbor 111.111.111.111 activate`	mode Activate vpls neighbor
`(config-router-af)#exit-address-family`	Exit from Address Family configuration
`(config-router)#address-family vrf l3vpnvrf300`	Configure VRF address family
`(config-router-af)#redistribute connected`	Redistribute connected addresses
`(config-router-af)#exit-address-family`	Exit from Address Family configuration
`(config-router)#exit`	Exit from router mode
`(config)#mpls vplsldp100 100`	Configuring VPLS instance with name and VPLS ID
`(config-vpls)#signaling ldp`	Enabling LDP signaling for the VPLS instance
`(config-vpls-sig)# vpls-peer 111.111.111.111`	Configuring VPLS mesh peers
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode
`(config-vpls)#exit-vpls`	Exit from VPLS mode
`(config)#mpls l2-circuit VPWS400 400 111.111.111.111`	Configuring VPWS instance with name and VPWS ID
`(config)#mpls vpls vplsbgp200 200`	Configuring VPLS instance with name and VPLS ID
`(config-vpls)#signaling bgp`	Enabling LDP signaling for the VPLS instance

`(config-vpls-sig)#ve-id 201`	Configure VE ID, which is mandatory for BGP VPLS,otherwise, signaling does not take place. VE ID should be unique per VPLS instance
`(config-vpls-sig)#exit-signaling`	Exit from VPLS signaling mode
`(config-vpls)#exit-vpls`	Exit from VPLS mode
`(config-if)#interface xe12.100 switchport`	Enter sub interface mode
`(config-if)#split-horizon group access1`	Configure split-horizon group on sub-interface
`(config-if)#encapsulation dot1q 100`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpls`	Access VPLS under sub interface
`(config-acc-if-vpls)#mpls-vpls vplsldp100`	Associating the VPLS Instance to the attachment circuit interface.
`(config-acc-if-vpls)#exit`	Exit from access mode
`(config-if)#interface xe12.400 switchport`	Enter sub interface mode
`(config-if)#encapsulation dot1q 400`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpws`	Access VPWS under sub interface
`(config-acc-if-vpws)#mpls-vpws VPWS400`	Associating the VPWS Instance to the attachment circuit interface.
`(config-acc-if-vpws)#exit`	Exit from access mode
`(config-if)#interface xe12.200 switchport`	Enter sub interface mode
`(config-if)#split-horizon group access1`	Configure split-horizon group on sub-interface
`(config-if)#encapsulation dot1q 200`	Configure encapsulation under a subinterface
`(config-if)#access-if-vpls`	Access VPLS under sub interface
`(config-acc-if-vpls)#mpls-vpls vplsbgp200`	Associating the VPLS Instance to the attachment circuit interface.
`(config-acc-if-vpls)#exit`	Exit from access mode
`(config-if)#interface xe12.300`	Enter sub interface mode
`(config-if)#encapsulation dot1q 300`	Configure encapsulation under a subinterface
`(config-if)#ip vrf forwarding l3vpnvrf300`	Attaching xe12.300 to as part of l3vpnvrf300
`(config-if)#ip address 210.210.210.1/24`	Configure the IP address of the interface.
`(config-if)#exit`	Exit interface mode
`(config)#commit`	Commit the configuration
`(config)#end`	Return to privilege mode

Validation

PE1

```
---
---
PE1#show ip ospf neighbor

Total number of full neighbors: 4
OSPF process 100 VRF(default):
```

```
Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID
11.11.11.11       1   Full/Backup     00:00:30    10.0.0.20      po1000.1000
0
11.11.11.11       1   Full/Backup     00:00:34    10.0.1.20      xe13
0
33.33.33.33       1   Full/Backup     00:00:34    16.0.0.20      xe4
0
33.33.33.33       1   Full/Backup     00:00:34    16.0.1.20      xe4.1001
0
PE1#

PE1#show ip ospf interface brief
Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
lo           100   0.0.0.0         1          1     Loopback        0            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe4          100   0.0.0.0         10005      10    DR              1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe13         100   0.0.0.0         10014      10    DR              1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
xe4.1001     100   0.0.0.0         327844841  10    DR              1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
po1000.1000  100   0.0.0.0         524289000  10    DR              1            Up

PE1#

PE1#show ldp session
Peer IP Address          IF Name    My Role    State       KeepAlive  UpTime
11.11.11.11              xe13       Active     OPERATIONAL   30    00:00:33
33.33.33.33              xe4.1001   Active     OPERATIONAL   30    00:00:33
222.222.222.222          xe4.1001   Passive    OPERATIONAL   30    00:00:22
PE1#


PE1#show bgp neighbors
BGP neighbor is 222.222.222.222, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 111.111.111.111, remote router ID 222.222.222.222
  BGP state = Established, up for 00:00:27
  Last read 00:00:08, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
    Address family L2VPN VPLS: advertised and received
    Address family L2VPN EVPN: advertised and received
    Address family IPv6 Unicast: advertised and received
    Address family VPNv6 Unicast: advertised and received
```

```
    Address family IPv6 Labeled Unicast: advertised and received
  Received 11 messages, 0 notifications, 0 in queue
  Sent 13 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo

 For address family: VPNv4 Unicast
  BGP table version 2, neighbor version 2
  Index 1, Offset 0, Mask 0x2
  AIGP is enabled
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  1 accepted prefixes
  1 announced prefixes

 For address family: L2VPN VPLS
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  0 accepted prefixes
  1 announced prefixes

 Connections established 1; dropped 0
Local host: 111.111.111.111, Local port: 179
Foreign host: 222.222.222.222, Foreign port: 35033
Nexthop: 111.111.111.111
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

PE1#
```

```
PE1#show mpls vpls
Name                            VPLS-ID     Type              MPeers    SPeers    SIG-
Protocol    Learning
vplsldp100                   100       Ethernet          1         0         LDP
Enabled
vplsbgp200                   200       Ethernet          1         0         BGP
Enabled
PE1#
```

```
PE1#show mpls vpls mesh
(m) - Service mapped over multipath transport

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
```

```
100       222.222.222.222   25611        26253     xe13          26246     2/Up
1         LDP            Active
200       222.222.222.222   25611        25608     xe13          25607     2/Up
3         BGP            Active
PE1#
```

```
PE1#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VC-ID      Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label
Nexthop         Status
400

PE1#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: VPWS400, id: 400  PW-INDEX: 2 service-tpid: dot1.q
 Endpoint: 222.222.222.222
 Control Word: 0
 Flow Label Status: Disabled, Direction: None, Static: No
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe8.400
 Subinterface Match Criteria(s) :
  dot1q 400
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active

PE1#
```

```
PE1#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type     Out-Label    Out-
Intf     Nexthop
   B>   210.210.210.0/24    1        -          -    LSP_DEFAULT  25664       -
222.222.222.222
   B>   210::/64           2        -          -    LSP_DEFAULT  25664       -
222.222.222.222
PE1#
```

```
PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP
```

```
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf     ELC    Nexthop
   L>   9.0.0.0/24          1         73(e)
                                    52        -           Yes   LSP_DEFAULT  3
xe13         No     10.0.1.20
                                    71        -           No    LSP_DEFAULT  0
xe4          No     222.222.222.222
                                                                                    (via
16.0.0.20 ,label 25612)
                                    53        -           Yes   LSP_DEFAULT  3
po1000.1000 No     10.0.0.20
                                    71        -           No    LSP_DEFAULT  0
xe4          No     222.222.222.222
                                                                                    (via
16.0.0.20 ,label 25612)
   L>   11.0.0.0/24         2         73(e)
                                    52        -           Yes   LSP_DEFAULT  3
xe13         No     10.0.1.20
                                    71        -           No    LSP_DEFAULT  0
xe4          No     222.222.222.222
                                                                                    (via
16.0.0.20 ,label 25612)
                                    53        -           Yes   LSP_DEFAULT  3
po1000.1000 No     10.0.0.20
                                    71        -           No    LSP_DEFAULT  0
xe4          No     222.222.222.222
                                                                                    (via
16.0.0.20 ,label 25612)
   L>   11.11.11.11/32      3         100(e)
                                    52        -           Yes   LSP_DEFAULT  3
xe13         No     10.0.1.20
                                    53        -           No    LSP_DEFAULT  3
po1000.1000 No     10.0.0.20
                                    53        -           Yes   LSP_DEFAULT  3
po1000.1000 No     10.0.0.20
                                    52        -           No    LSP_DEFAULT  3
xe13         No     10.0.1.20
   L>   15.0.0.0/24         4         77(e)
                                    56        -           Yes   LSP_DEFAULT  25600
xe13         No     10.0.1.20
                                    71        -           No    LSP_DEFAULT  0
xe4          No     222.222.222.222
                                                                                    (via
16.0.0.20 ,label 25612)
                                    57        -           Yes   LSP_DEFAULT  25600
po1000.1000 No     10.0.0.20
                                    71        -           No    LSP_DEFAULT  0
xe4          No     222.222.222.222
                                                                                    (via
16.0.0.20 ,label 25612)
   L>   15.0.1.0/24         5         80(e)
                                    60        -           Yes   LSP_DEFAULT  25601
xe13         No     10.0.1.20
                                    71        -           No    LSP_DEFAULT  0
xe4          No     222.222.222.222
```

```
                                                                                         (via
16.0.0.20 ,label 25612)
                                   61       -          Yes   LSP_DEFAULT  25601
po1000.1000 No    10.0.0.20
                                   71       -          No    LSP_DEFAULT  0
xe4         No    222.222.222.222
                                                                                         (via
16.0.0.20 ,label 25612)
   L>   17.0.0.0/24         6         84(e)
                                   16       -          Yes   LSP_DEFAULT  3
xe4         No    16.0.0.20
                                   82       -          No    LSP_DEFAULT  26249
po1000.1000 No    222.222.222.222
                                                                                         (via
10.0.0.20 ,label 25611)
                                   17       -          Yes   LSP_DEFAULT  3
xe4.1001    No    16.0.1.20
                                   82       -          No    LSP_DEFAULT  26249
po1000.1000 No    222.222.222.222
                                                                                         (via
10.0.0.20 ,label 25611)
   L>   18.0.0.0/24         7         88(e)
                                   19       -          Yes   LSP_DEFAULT  25608
xe4         No    16.0.0.20
                                   86       -          No    LSP_DEFAULT  0
po1000.1000 No    222.222.222.222
                                                                                         (via
10.0.0.20 ,label 25611)
                                   20       -          Yes   LSP_DEFAULT  25608
xe4.1001    No    16.0.1.20
                                   86       -          No    LSP_DEFAULT  0
po1000.1000 No    222.222.222.222
                                                                                         (via
10.0.0.20 ,label 25611)
   L>   18.0.1.0/24         8         91(e)
                                   22       -          Yes   LSP_DEFAULT  25609
xe4         No    16.0.0.20
                                   86       -          No    LSP_DEFAULT  0
po1000.1000 No    222.222.222.222
                                                                                         (via
10.0.0.20 ,label 25611)
                                   23       -          Yes   LSP_DEFAULT  25609
xe4.1001    No    16.0.1.20
                                   86       -          No    LSP_DEFAULT  0
po1000.1000 No    222.222.222.222
                                                                                         (via
10.0.0.20 ,label 25611)
   L>   22.22.22.22/32      9         94(e)
                                   64       -          Yes   LSP_DEFAULT  25607
xe13        No    10.0.1.20
                                   71       -          No    LSP_DEFAULT  0
xe4         No    222.222.222.222
                                                                                         (via
16.0.0.20 ,label 25612)
                                   65       -          Yes   LSP_DEFAULT  25607
po1000.1000 No    10.0.0.20
```

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```
                                             71        -          No    LSP_DEFAULT  0
xe4         No    222.222.222.222
                                                                                      (via
16.0.0.20 ,label 25612)
   L>   33.33.33.33/32      10       102(e)
                                             16        -          Yes   LSP_DEFAULT  3
xe4         No    16.0.0.20
                                             17        -          No    LSP_DEFAULT  3
xe4.1001    No    16.0.1.20
                                             17        -          Yes   LSP_DEFAULT  3
xe4.1001    No    16.0.1.20
                                             16        -          No    LSP_DEFAULT  3
xe4         No    16.0.0.20
   L>   44.44.44.44/32      11       98(e)
                                             28        -          Yes   LSP_DEFAULT  25611
xe4         No    16.0.0.20
                                             96        -          No    LSP_DEFAULT  26251
po1000.1000 No    222.222.222.222
                                                                                      (via
10.0.0.20 ,label 25611)
                                             29        -          Yes   LSP_DEFAULT  25611
xe4.1001    No    16.0.1.20
                                             96        -          No    LSP_DEFAULT  26251
po1000.1000 No    222.222.222.222
                                                                                      (via
10.0.0.20 ,label 25611)
   L>   222.222.222.222/32  12       104(e)
                                             68        -          Yes   LSP_DEFAULT  25611
xe13        Yes   10.0.1.20
                                             31        -          No    LSP_DEFAULT  25612
xe4         Yes   16.0.0.20
                                             69        -          Yes   LSP_DEFAULT  25611
po1000.1000 Yes   10.0.0.20
                                             31        -          No    LSP_DEFAULT  25612
xe4         Yes   16.0.0.20
                                             31        -          Yes   LSP_DEFAULT  25612
xe4         Yes   16.0.0.20
                                             69        -          No    LSP_DEFAULT  25611
po1000.1000 Yes   10.0.0.20
                                             32        -          Yes   LSP_DEFAULT  25612
xe4.1001    Yes   16.0.1.20
                                             69        -          No    LSP_DEFAULT  25611
po1000.1000 Yes   10.0.0.20
   B>   220::/64            13       49        -          -     LSP_DEFAULT  25665
-           No    222.222.222.222
PE1#
```

```
PE1#show interface counters rate mbps
+--------------------+---------------+--------------+---------------+--------------+
|     Interface      |    Rx mbps    |    Rx pps    |    Tx mbps    |    Tx pps    |
+--------------------+---------------+--------------+---------------+--------------+
 po1000               350.55          4850          250.40          3466
 po1000.1000          350.55          4851          250.39          3465
 xe0                  0.00            0             0.00            0
```

```
 xe2                0.00           0             0.00           0
 xe4                400.63         5546          500.68         6932
 xe4.1001           400.63         5545          250.40         3465
 xe8                997.81         13858         997.81         13858
 xe8.400            997.80         13858         997.80         13858
 xe12               350.56         4850          250.40         3466
 xe13               250.28         3467          250.29         3466
PE1#
```

P1

```
---


P1#show ip ospf interface brief
Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
lo            100   0.0.0.0         1          1     Loopback        0            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
ge8           100   0.0.0.0         10009      20    Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
ge13          100   0.0.0.0         10014      10    Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
po1000.1000   100   0.0.0.0         524289000  10    Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
po2000.100    100   0.0.0.0         557056100  10    Backup          1            Up

P1#

P1#show ip ospf neighbor

Total number of full neighbors: 4
OSPF process 100 VRF(default):
Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID
222.222.222.222   1   Full/DR         00:00:38    9.0.0.20        ge8
0
111.111.111.111   1   Full/DR         00:00:36    10.0.0.10       po1000.1000
0
111.111.111.111   1   Full/DR         00:00:34    10.0.1.10       ge13
0
22.22.22.22       1   Full/DR         00:00:38    11.0.0.20       po2000.100
0
P1#

P1#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
22.22.22.22               po2000.100 Passive   OPERATIONAL   30    00:01:27
```

```
222.222.222.222          ge8        Passive   OPERATIONAL   30    00:00:19
111.111.111.111          ge13       Passive   OPERATIONAL   30    00:00:32
33.33.33.33              ge13       Passive   OPERATIONAL   30    00:00:21
44.44.44.44              po2000.100 Passive   OPERATIONAL   30    00:00:14
P1#

P1#show interface counters rate mbps
+--------------------+--------------+-------------+--------------+-------------+
|     Interface      |    Rx mbps   |    Rx pps   |    Tx mbps   |    Tx pps   |
+--------------------+--------------+-------------+--------------+-------------+
 ge8                  190.14         2634          250.19         3464
 ge10                 0.00           0             0.00           0
 ge12                 250.30         3465          350.42         4848
 ge13                 250.19         3465          250.19         3465
 po1000               250.30         3465          350.42         4849
 po1000.1000          250.31         3465          350.42         4848
 po2000               410.50         5680          250.30         3464
 po2000.100           410.50         5681          250.30         3464
 xe23                 220.26         3048          120.15         1663
 xe24                 190.23         2632          130.16         1801
 xe26                 0.00           0             0.00           0
P1#


P1#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

LDP ilm-ecmp - enabled
Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-Intf/VRF
Nexthop                  pri    LSP-Type
   L>   111.111.111.111/32 22          25621       0           N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                     25621       0           N/A        po1000.1000
10.0.0.10                No     LSP_DEFAULT
                                     25621       0           N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
                                     25621       0           N/A        ge13
10.0.1.10                No     LSP_DEFAULT
   L>   16.0.1.0/24       9          25608       0           N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                     25608       0           N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   15.0.0.0/24       3          25602       3           N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                     25602       0           N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
   L>   15.0.1.0/24       2          25601       3           N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
```

```
                                      25601      0           N/A        ge8
9.0.0.20                No     LSP_DEFAULT
   L>   15.0.0.0/24       1          25600      3           N/A        po2000.100
11.0.0.20               Yes    LSP_DEFAULT
                                      25600      0           N/A        ge8
9.0.0.20                No     LSP_DEFAULT
   L>   16.0.0.0/24       5          25604      0           N/A        ge13
10.0.1.10               Yes    LSP_DEFAULT
                                      25604      0           N/A        po1000.1000
10.0.0.10               Yes    LSP_DEFAULT
   L>   15.0.1.0/24       4          25603      3           N/A        po2000.100
11.0.0.20               Yes    LSP_DEFAULT
                                      25603      0           N/A        ge8
9.0.0.20                No     LSP_DEFAULT
   L>   18.0.1.0/24       7          25606      25604       N/A        po2000.100
11.0.0.20               Yes    LSP_DEFAULT
                                      25606      0           N/A        ge8
9.0.0.20                Yes    LSP_DEFAULT
                                      25606      3           N/A        ge8
44.44.44.44             No     LSP_DEFAULT
                                                                                   (via
9.0.0.20 ,label 26269)
   L>   18.0.0.0/24       6          25605      25603       N/A        po2000.100
11.0.0.20               Yes    LSP_DEFAULT
                                      25605      0           N/A        ge8
9.0.0.20                Yes    LSP_DEFAULT
                                      25605      3           N/A        ge8
44.44.44.44             No     LSP_DEFAULT
                                                                                   (via
9.0.0.20 ,label 26269)
   L>   22.22.22.22/32    8          25607      3           N/A        po2000.100
11.0.0.20               Yes    LSP_DEFAULT
                                      25607      26267       N/A        ge8
9.0.0.20                No     LSP_DEFAULT
   L>   111.111.111.111/32 17        25616      0           N/A        ge13
10.0.1.10               Yes    LSP_DEFAULT
                                      25616      0           N/A        po1000.1000
10.0.0.10               No     LSP_DEFAULT
                                      25616      0           N/A        po1000.1000
10.0.0.10               Yes    LSP_DEFAULT
                                      25616      0           N/A        ge13
10.0.1.10               No     LSP_DEFAULT
   L>   16.0.1.0/24       14         25613      0           N/A        ge13
10.0.1.10               Yes    LSP_DEFAULT
                                      25613      0           N/A        po1000.1000
10.0.0.10               Yes    LSP_DEFAULT
   L>   18.0.0.0/24       11         25610      25603       N/A        po2000.100
11.0.0.20               Yes    LSP_DEFAULT
                                      25610      0           N/A        ge8
9.0.0.20                Yes    LSP_DEFAULT
   L>   17.0.0.0/24       10         25609      26245       N/A        ge13
10.0.1.10               Yes    LSP_DEFAULT
                                      25609      26245       N/A        po1000.1000
10.0.0.10               Yes    LSP_DEFAULT
   L>   16.0.0.0/24       13         25612      0           N/A        ge13
10.0.1.10               Yes    LSP_DEFAULT
```

```
                                    25612      0          N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   222.222.222.222/32 12         25611      25607      N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                    25611      0          N/A        ge8
9.0.0.20                 Yes    LSP_DEFAULT
                                    25611      25624      N/A        ge8
44.44.44.44              No     LSP_DEFAULT
                                                                                 (via
9.0.0.20 ,label 26269)
   L>   17.0.0.0/24       15          25614      26245      N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                    25614      3          N/A        ge8
44.44.44.44              No     LSP_DEFAULT
                                                                                 (via
9.0.0.20 ,label 26269)
                                    25614      26245      N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
                                    25614      3          N/A        ge8
44.44.44.44              No     LSP_DEFAULT
                                                                                 (via
9.0.0.20 ,label 26269)
   L>   33.33.33.33/32    16          25615      26249      N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                    25615      25622      N/A        ge8
44.44.44.44              No     LSP_DEFAULT
                                                                                 (via
9.0.0.20 ,label 26269)
                                    25615      26249      N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
                                    25615      25622      N/A        ge8
44.44.44.44              No     LSP_DEFAULT
                                                                                 (via
9.0.0.20 ,label 26269)
   L>   22.22.22.22/32    19          25618      3          N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                    25618      26267      N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
   L>   18.0.1.0/24       18          25617      25604      N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                    25617      0          N/A        ge8
9.0.0.20                 Yes    LSP_DEFAULT
   L>   33.33.33.33/32    20          25619      26249      N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                    25619      26249      N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   44.44.44.44/32    21          25620      25606      N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                    25620      26269      N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
                                    25620      26250      N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                    25620      26269      N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
                                    25620      26250      N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
```

```
                                       25620      26269      N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
                                       25620      26269      N/A        ge8
9.0.0.20                 Yes    LSP_DEFAULT
                                       25620      26250      N/A        po1000.1000
10.0.0.10                No     LSP_DEFAULT
   L>   33.33.33.33/32     32          25631      26249      N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                       25631      26249      N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   16.0.0.0/24        26          25625      0          N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                       25625      0          N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   15.0.0.0/24        24          25623      3          N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                       25623      0          N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
   L>   222.222.222.222/32 23          25622      25607      N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                       25622      0          N/A        ge8
9.0.0.20                 Yes    LSP_DEFAULT
   L>   15.0.1.0/24        25          25624      3          N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                       25624      0          N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
   L>   17.0.0.0/24        28          25627      26245      N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                       25627      26245      N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   16.0.1.0/24        27          25626      0          N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                       25626      0          N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   18.0.1.0/24        30          25629      25604      N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                       25629      0          N/A        ge8
9.0.0.20                 Yes    LSP_DEFAULT
   L>   18.0.0.0/24        29          25628      25603      N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                       25628      0          N/A        ge8
9.0.0.20                 Yes    LSP_DEFAULT
   L>   22.22.22.22/32     31          25630      3          N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                       25630      26267      N/A        ge8
9.0.0.20                 No     LSP_DEFAULT
   L>   16.0.0.0/24        38          25637      0          N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                       25637      0          N/A        po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   15.0.0.0/24        36          25635      3          N/A        po2000.100
11.0.0.20                Yes    LSP_DEFAULT
   L>   111.111.111.111/32 34          25633      0          N/A        ge13
10.0.1.10                Yes    LSP_DEFAULT
                                       25633      0          N/A        po1000.1000
10.0.0.10                No     LSP_DEFAULT
```

```
                                  25633       0           N/A         po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
                                  25633       0           N/A         ge13
10.0.1.10                No     LSP_DEFAULT
   L>  44.44.44.44/32     33      25632       25606       N/A         po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                  25632       26269       N/A         ge8
9.0.0.20                 No     LSP_DEFAULT
                                  25632       26250       N/A         ge13
10.0.1.10                Yes    LSP_DEFAULT
                                  25632       26269       N/A         ge8
9.0.0.20                 No     LSP_DEFAULT
                                  25632       26250       N/A         po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
                                  25632       26269       N/A         ge8
9.0.0.20                 No     LSP_DEFAULT
                                  25632       26269       N/A         ge8
9.0.0.20                 Yes    LSP_DEFAULT
                                  25632       26250       N/A         po1000.1000
10.0.0.10                No     LSP_DEFAULT
   L>   222.222.222.222/32 35     25634       25607       N/A         po2000.100
11.0.0.20                Yes    LSP_DEFAULT
                                  25634       0           N/A         ge8
9.0.0.20                 Yes    LSP_DEFAULT
   L>   15.0.1.0/24       37      25636       3           N/A         po2000.100
11.0.0.20                Yes    LSP_DEFAULT
   L>   22.22.22.22/32    41      25640       3           N/A         po2000.100
11.0.0.20                Yes    LSP_DEFAULT
   L>   16.0.1.0/24       39      25638       0           N/A         ge13
10.0.1.10                Yes    LSP_DEFAULT
                                  25638       0           N/A         po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
   L>   17.0.0.0/24       40      25639       26245       N/A         ge13
10.0.1.10                Yes    LSP_DEFAULT
                                  25639       3           N/A         ge8
44.44.44.44              No     LSP_DEFAULT
                                                                                     (via
9.0.0.20 ,label 26269)
                                  25639       26245       N/A         po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
                                  25639       3           N/A         ge8
44.44.44.44              No     LSP_DEFAULT
                                                                                     (via
9.0.0.20 ,label 26269)
   L>   111.111.111.111/32 43     25642       0           N/A         ge13
10.0.1.10                Yes    LSP_DEFAULT
                                  25642       0           N/A         po1000.1000
10.0.0.10                No     LSP_DEFAULT
                                  25642       0           N/A         po1000.1000
10.0.0.10                Yes    LSP_DEFAULT
                                  25642       0           N/A         ge13
10.0.1.10                No     LSP_DEFAULT
   L>   33.33.33.33/32    42      25641       26249       N/A         ge13
10.0.1.10                Yes    LSP_DEFAULT
                                  25641       25622       N/A         ge8
44.44.44.44              No     LSP_DEFAULT
```

```
                                                                              (via
9.0.0.20 ,label 26269)
                                     25641      26249      N/A       po1000.1000
10.0.0.10              Yes    LSP_DEFAULT
                                     25641      25622      N/A       ge8
44.44.44.44            No     LSP_DEFAULT
                                                                              (via
9.0.0.20 ,label 26269)
P1#
```

P2

```
---
P2#show ip ospf interface brief
Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
lo           100   0.0.0.0         1          1     Loopback        0            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
ge6.300      100   0.0.0.0         328171820  10    Backup          1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
ge6.1001     100   0.0.0.0         328172521  10    Backup          1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
po2000.100   100   0.0.0.0         557056100  10    DR              1            Up

P2#

P2#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
11.11.11.11       1   Full/Backup     00:00:32    11.0.0.10       po2000.100
0
222.222.222.222   1    Full/DR         00:00:36    15.0.0.20       ge6.300
0
222.222.222.222   1    Full/DR         00:00:35    15.0.1.20       ge6.1001
0
P2#


P2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
222.222.222.222           ge6.1001   Passive   OPERATIONAL   30    00:00:21
11.11.11.11               po2000.100 Active    OPERATIONAL   30    00:01:27
33.33.33.33               po2000.100 Passive   OPERATIONAL   30    00:00:14
P2#
P3
---
P3#show ip ospf interface brief
Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
```

```
lo            100   0.0.0.0         1          1     Loopback        0            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
ge5           100   0.0.0.0         10014      10    Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
ge5.1001      100   0.0.0.0         328139753  10    Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
sa4000.200    100   0.0.0.0         1179648200 10    Backup          1            Up

P3#

P3#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
111.111.111.111   1   Full/DR         00:00:38    16.0.0.10       ge5
0
111.111.111.111   1   Full/DR         00:00:32    16.0.1.10       ge5.1001
0
44.44.44.44       1   Full/DR         00:00:36    17.0.0.10       sa4000.200
0
P3#

P3#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
44.44.44.44               sa4000.200 Passive   OPERATIONAL   30    00:02:00
111.111.111.111           ge5        Passive   OPERATIONAL   30    00:00:32
22.22.22.22               ge5        Active    OPERATIONAL   30    00:00:14
11.11.11.11               ge5        Active    OPERATIONAL   30    00:00:20
222.222.222.222           sa4000.200 Passive   OPERATIONAL   30    00:00:13
P3#
P4
---
P4#show ip ospf interface brief
Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
lo            100   0.0.0.0         1          1     Loopback        0            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
sa3000        100   0.0.0.0         203000     10    Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
sa3000.1001   100   0.0.0.0         1146881001 10    Backup          1            Up

Interface     PID   Area            Intf ID    Cost  State           Neighbors  Status
sa4000.200    100   0.0.0.0         1179648200 10    DR              1            Up

P4#
```

```
P4#show ip ospf neighbor

Total number of full neighbors: 3
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
33.33.33.33       1   Full/Backup      00:00:34    17.0.0.20       sa4000.200
0
222.222.222.222   1   Full/DR          00:00:36    18.0.0.20       sa3000
0
222.222.222.222   1   Full/DR          00:00:34    18.0.1.20       sa3000.1001
0
P4#


P4#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
222.222.222.222           sa3000     Passive   OPERATIONAL   30    00:00:40
33.33.33.33               sa4000.200 Active    OPERATIONAL   30    00:02:00
11.11.11.11               sa4000.200 Active    OPERATIONAL   30    00:00:14
P4#
```

PE2

```
---

PE2#show ip ospf neighbor

Total number of full neighbors: 5
OSPF process 100 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
11.11.11.11       1   Full/Backup      00:00:36    9.0.0.10        ge9
0
22.22.22.22       1   Full/Backup      00:00:31    15.0.0.10       xe14.1002
0
22.22.22.22       1   Full/Backup      00:00:34    15.0.1.10       xe14.1001
0
44.44.44.44       1   Full/Backup      00:00:38    18.0.0.10       sa3000
0
44.44.44.44       1   Full/Backup      00:00:31    18.0.1.10       sa3000.1001
0
PE2#

PE2#show ip ospf interface brief
Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
lo           100   0.0.0.0         1          1     Loopback        0            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
ge9          100   0.0.0.0         10018      20    DR              1            Up

Interface    PID   Area            Intf ID    Cost  State           Neighbors  Status
```

```
sa3000       100   0.0.0.0        203000     10    DR              1           Up

Interface    PID   Area           Intf ID    Cost  State           Neighbors  Status
xe14.1001    100   0.0.0.0        328434665  10    DR              1           Up

Interface    PID   Area           Intf ID    Cost  State           Neighbors  Status
xe14.1002    100   0.0.0.0        328434666  10    DR              1           Up

Interface    PID   Area           Intf ID    Cost  State           Neighbors  Status
sa3000.1001  100   0.0.0.0        1146881001 10    DR              1           Up

PE2#


PE2#show ldp session
Peer IP Address           IF Name    My Role    State      KeepAlive  UpTime
44.44.44.44               sa3000     Active    OPERATIONAL   30    00:00:41
11.11.11.11               ge9        Active    OPERATIONAL   30    00:00:18
22.22.22.22               xe14.1002  Active    OPERATIONAL   30    00:00:25
111.111.111.111           xe14.1001  Active    OPERATIONAL   30    00:00:22
33.33.33.33               sa3000     Active    OPERATIONAL   30    00:00:14
PE2#


PE2#show bgp neighbors
BGP neighbor is 111.111.111.111, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 222.222.222.222, remote router ID 111.111.111.111
  BGP state = Established, up for 00:00:27
  Last read 00:00:01, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
    Address family L2VPN VPLS: advertised and received
    Address family L2VPN EVPN: advertised and received
    Address family IPv6 Unicast: advertised and received
    Address family VPNv6 Unicast: advertised and received
    Address family IPv6 Labeled Unicast: advertised and received
  Received 12 messages, 0 notifications, 0 in queue
  Sent 11 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 5 seconds
  Update source is lo

 For address family: VPNv4 Unicast
  BGP table version 2, neighbor version 2
  Index 1, Offset 0, Mask 0x2
  AIGP is enabled
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
```

```
  1 accepted prefixes
  1 announced prefixes

 For address family: L2VPN VPLS
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  0 accepted prefixes
  1 announced prefixes

 Connections established 1; dropped 0
Local host: 222.222.222.222, Local port: 35033
Foreign host: 111.111.111.111, Foreign port: 179
Nexthop: 222.222.222.222
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

PE2#

PE2#show mpls vpls
Name                            VPLS-ID     Type             MPeers    SPeers    SIG-
Protocol    Learning
vplsldp100                   100       Ethernet           1         0         LDP
Enabled
vplsbgp200                   200       Ethernet           1         0         BGP
Enabled
PE2#



PE2#show mpls vpls mesh
(m) - Service mapped over multipath transport

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol  Status
100       111.111.111.111   25614         26246      sa3000.1001    26253      2/Up
1         LDP           Active
200       111.111.111.111   25614         25607      sa3000.1001    25608      2/Up
3         BGP           Active
PE2#

PE2#show mpls vc-table
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VC-ID      Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label  Tunnel-Label
Nexthop         Status
400        N/A      N/A            xe12.400      N/A (e)       26252      N/A (e)
111.111.111.111 Active
PE2#
```

```
PE2#show mpls l2-circuit
MPLS Layer-2 Virtual Circuit: VPWS400, id: 400  PW-INDEX: 2 service-tpid: dot1.q
 Endpoint: 111.111.111.111
 Control Word: 0
 Flow Label Status: Disabled, Direction: None, Static: No
 MPLS Layer-2 Virtual Circuit Group: none
 Bound to interface: xe12.400
 Subinterface Match Criteria(s) :
  dot1q 400
 Virtual Circuit Type: Ethernet VLAN
 Virtual Circuit is configured as Primary
 Virtual Circuit is configured as Active
 Virtual Circuit is active

PE2#
```

```
PE2#show mpls vrf-forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN
(m) - Service mapped over multipath transport

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type     Out-Label    Out-
Intf     Nexthop
   B>   110.110.110.0/24    2        -          -    LSP_DEFAULT  25664       -
111.111.111.111
   B>   110::/64          1        -          -    LSP_DEFAULT  25664       -
111.111.111.111
PE2#
```

```
PE2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L>   10.0.0.0/24         8         56(e)
                                    54        -          Yes   LSP_DEFAULT  25617
xe14.1001   No    15.0.1.10
                                    33        -          No    LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    55        -          Yes   LSP_DEFAULT  25617
xe14.1002   No    15.0.0.10
                                    33        -          No    LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    33        -          Yes   LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    38        -          No    LSP_DEFAULT  0
ge9         No    111.111.111.111
```

```
                                                                                      (via
9.0.0.10 ,label 25642)
   L>   10.0.1.0/24         9        59(e)
                                    57        -          Yes   LSP_DEFAULT  25618
xe14.1001   No    15.0.1.10
                                    33        -          No    LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    58        -          Yes   LSP_DEFAULT  25618
xe14.1002   No    15.0.0.10
                                    33        -          No    LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    33        -          Yes   LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    38        -          No    LSP_DEFAULT  0
ge9         No    111.111.111.111
                                                                                      (via
9.0.0.10 ,label 25642)
   L>   11.0.0.0/24         11       63(e)
                                    60        -          Yes   LSP_DEFAULT  3
xe14.1001   No    15.0.1.10
                                    61        -          Yes   LSP_DEFAULT  3
xe14.1002   No    15.0.0.10
                                    62        -          No    LSP_DEFAULT  26255
ge9         No    111.111.111.111
                                                                                      (via
9.0.0.10 ,label 25642)
   L>   11.11.11.11/32      10       68(e)
                                    66        -          Yes   LSP_DEFAULT  25619
xe14.1001   No    15.0.1.10
                                    33        -          No    LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    67        -          Yes   LSP_DEFAULT  25619
xe14.1002   No    15.0.0.10
                                    33        -          No    LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    33        -          Yes   LSP_DEFAULT  3
ge9         No    9.0.0.10
                                    40        -          No    LSP_DEFAULT  26256
ge9         No    111.111.111.111
                                                                                      (via
9.0.0.10 ,label 25642)
   L>   16.0.0.0/24         1        42(e)
                                    1         -          Yes   LSP_DEFAULT  25604
sa3000.1001 No    18.0.1.10
                                    38        -          No    LSP_DEFAULT  0
ge9         No    111.111.111.111
                                                                                      (via
9.0.0.10 ,label 25642)
                                    2         -          Yes   LSP_DEFAULT  25604
sa3000      No    18.0.0.10
                                    38        -          No    LSP_DEFAULT  0
ge9         No    111.111.111.111
                                                                                      (via
9.0.0.10 ,label 25642)
   L>   16.0.1.0/24         2        43(e)
```

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```
                                    4        -          Yes   LSP_DEFAULT  25605
sa3000.1001 No    18.0.1.10
                                    38       -          No    LSP_DEFAULT  0
ge9         No    111.111.111.111
                                                                                (via
9.0.0.10 ,label 25642)
                                    5        -          Yes   LSP_DEFAULT  25605
sa3000      No    18.0.0.10
                                    38       -          No    LSP_DEFAULT  0
ge9         No    111.111.111.111
                                                                                (via
9.0.0.10 ,label 25642)
   L>   17.0.0.0/24        3          53(e)
                                    7        -          Yes   LSP_DEFAULT  3
sa3000.1001 No    18.0.1.10
                                    52       -          No    LSP_DEFAULT  3
ge9         No    33.33.33.33
                                                                                (via
9.0.0.10 ,label 25641)
                                    8        -          Yes   LSP_DEFAULT  3
sa3000      No    18.0.0.10
                                    52       -          No    LSP_DEFAULT  3
ge9         No    33.33.33.33
                                                                                (via
9.0.0.10 ,label 25641)
   L>   22.22.22.22/32     12         69(e)
                                    60       -          Yes   LSP_DEFAULT  3
xe14.1001   No    15.0.1.10
                                    61       -          No    LSP_DEFAULT  3
xe14.1002   No    15.0.0.10
                                    61       -          Yes   LSP_DEFAULT  3
xe14.1002   No    15.0.0.10
                                    60       -          No    LSP_DEFAULT  3
xe14.1001   No    15.0.1.10
   L>   33.33.33.33/32     4          45(e)
                                    10       -          Yes   LSP_DEFAULT  25606
sa3000.1001 No    18.0.1.10
                                    44       -          No    LSP_DEFAULT  26263
ge9         No    111.111.111.111
                                                                                (via
9.0.0.10 ,label 25642)
                                    11       -          Yes   LSP_DEFAULT  25606
sa3000      No    18.0.0.10
                                    44       -          No    LSP_DEFAULT  26263
ge9         No    111.111.111.111
                                                                                (via
9.0.0.10 ,label 25642)
   L>   44.44.44.44/32     5          31(e)
                                    7        -          Yes   LSP_DEFAULT  3
sa3000.1001 No    18.0.1.10
                                    8        -          No    LSP_DEFAULT  3
sa3000      No    18.0.0.10
                                    8        -          Yes   LSP_DEFAULT  3
sa3000      No    18.0.0.10
                                    7        -          No    LSP_DEFAULT  3
sa3000.1001 No    18.0.1.10
```

```
   L>   111.111.111.111/32  6         73(e)
                                   71        -           Yes   LSP_DEFAULT  25622
xe14.1001   Yes   15.0.1.10
                                   36        -           No    LSP_DEFAULT  25642
ge9         Yes   9.0.0.10
                                   72        -           Yes   LSP_DEFAULT  25622
xe14.1002   Yes   15.0.0.10
                                   36        -           No    LSP_DEFAULT  25642
ge9         Yes   9.0.0.10
                                   36        -           Yes   LSP_DEFAULT  25642
ge9         Yes   9.0.0.10
                                   17        -           No    LSP_DEFAULT  25614
sa3000      Yes   18.0.0.10
                                   16        -           Yes   LSP_DEFAULT  25614
sa3000.1001 Yes   18.0.1.10
                                   36        -           No    LSP_DEFAULT  25642
ge9         Yes   9.0.0.10
                                   17        -           Yes   LSP_DEFAULT  25614
sa3000      Yes   18.0.0.10
                                   36        -           No    LSP_DEFAULT  25642
ge9         Yes   9.0.0.10
   B>   120::/64          7         23        -           -     LSP_DEFAULT  25665
-           No    111.111.111.111
PE2#

PE2#show interface counters rate mbps
+-------------------+--------------+-------------+--------------+-------------+
|     Interface     |    Rx mbps   |    Rx pps   |    Tx mbps   |    Tx pps   |
+-------------------+--------------+-------------+--------------+-------------+
 ge4                  0.00           0             0.00           0
 ge5                  240.28         3327          210.29         2913
 ge6                  0.00           0             0.00           0
 ge7                  260.29         3603          190.27         2635
 ge9                  250.29         3466          190.22         2635
 ge10                 0.00           0             0.00           0
 sa3000               500.58         6930          400.56         5548
 sa3000.1001          0.00           0             200.33         2774
 xe12                 997.83         13858         997.83         13858
 xe12.400             997.83         13858         997.83         13858
 xe14                 250.40         3468          410.66         5685
 xe14.1001            0.00           1             58.53          811
 xe14.1002            250.40         3467          200.33         2772
PE2#
```

CHAPTER 9 LDP Graceful Restart

LDP graceful restart (GR) minimizes the negative effects on MPLS traffic caused by control-plane restarts in Label Switching Routers (LSR), especially by the restart of the Label Distribution Protocol (LDP).

LDP graceful restart enables a router whose LDP control plane is undergoing a restart to continue forwarding traffic while recovering its state from neighboring routers. This requires a restarting LDP router that retains established LSP labels. In helper mode, the router maintains label bindings as stale and reprocesses them, after the router undergoing graceful restart reestablishes its LDP session.

The MPLS forwarding state, which is the minimum state required to avoid any disturbance to LSPs traversing a restarting LSR, is preserved during the restart. This mechanism does not require any of the LDP-related states to be preserved across the restart. This means that when LDP restarts, there are minimal or no changes made to the forwarding table entries, and MPLS forwarding continues uninterrupted. This supports Graceful Restart in restarting routers as well as in neighbor routers.

Topology

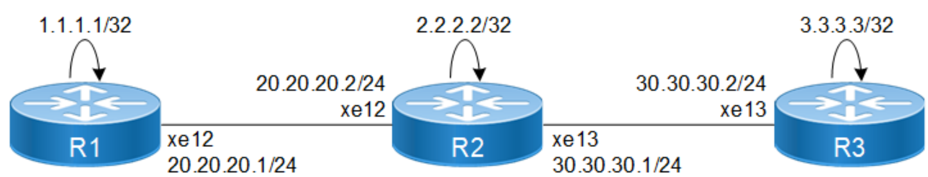


Figure 9-10: LDP Graceful Restart

Configuration

R1

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter Interface mode for loopback.
`(config-if)# ip address 1.1.1.1/32 secondary`	Assign secondary IP address.
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)# router ldp`	Enter the Router LDP mode
`(config-router)# router-id 1.1.1.1`	Assign router id for LDP
`(config-router)# graceful-restart full`	Enable graceful restart in LDP configure mode
`(config-router)# graceful-restart timers neighbor-liveness 130`	Configuring graceful neighbor-liveness timer to 130 sec.
`(config-router)# graceful-restart timers max-recovery 150`	Configuring graceful max recovery timer to 150 sec
`(config-router)# exit`	Exit Router LDP mode and return to Configure mode.
`(config)#interface ce49`	Enter Interface mode for ce49.
`(config-if)# ip address 20.20.20.1/24`	Assign IP address on ce49 interface.
`(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)# label-switching`	Enable Label switching on the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.

`(config)# router ospf`	Enter the Router OSPF mode
`(config-router)# network 1.1.1.1/32 area 0.0.0.0`	Advertise loopback address in OSPF
`(config-router)# network 20.20.20.0/24 area 0.0.0.0`	Advertise network address in OSPF
`(config-router)# redistribute connected`	Configure redistribution connected.
`(config-router)#exit`	Exit from Router OSPF mode and enter into config mode
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#exit`	Exit from configuration mode

R2

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter Interface mode for loopback.
`(config-if)# ip address 2.2.2.2/32 secondary`	Assign secondary IP address.
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)# router ldp`	Enter the Router LDP mode
`(config-router)# router-id 2.2.2.2`	Assign router id for LDP
`(config-router)# graceful-restart helper-only`	Enable graceful restart helper in LDP configure mode
`(config-router)# exit`	Exit Router LDP mode and return to Configure `mode`.
`(config)#interface ce0`	Enter Interface mode for ce0.
`(config-if)# ip address 20.20.20.2/24`	Assign IP address on ce0 interface.
`(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)# label-switching`	Enable Label switching on the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)#interface xe13`	Enter Interface mode for xe13.
`(config-if)# ip address 30.30.30.1/24`	Assign IP address on xe13 interface.
`(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)# label-switching`	Enable Label switching on the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)# router ospf`	Enter the Router OSPF mode
`(config-router)# network 2.2.2.2/32 area 0.0.0.0`	Advertise loopback address in OSPF
`(config-router)# network 20.20.20.0/24 area 0.0.0.0`	Advertise network address in OSPF
`(config-router)# network 30.30.30.0/24 area 0.0.0.0`	Advertise network address in OSPF
`(config-router)#exit`	Exit from Router OSPF mode and enter into config mode
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#exit`	Exit from configuration mode

R3

`#configure terminal`	Enter Configure mode.
`(config)#interface lo`	Enter Interface mode for loopback.
`(config-if)# ip address 3.3.3.3/32 secondary`	Assign secondary IP address.
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)# router ldp`	Enter the Router LDP mode
`(config-router)# router-id 3.3.3.3`	Assign router id for LDP
`(config-router)# graceful-restart helper-only`	Enable graceful restart helper in LDP configure mode
`(config-router)# exit`	Exit Router LDP mode and return to Configure mode.
`(config)#interface xe13`	Enter Interface mode for xe13.
`(config-if)# ip address 30.30.30.2/24`	Assign IP address on xe13 interface.
`(config-if)# enable-ldp ipv4`	Enable LDP on the interface.
`(config-if)# label-switching`	Enable Label switching on the interface
`(config-if)#exit`	Exit Interface mode and return to Configure mode.
`(config)# router ospf`	Enter the Router OSPF mode
`(config-router)# network 3.3.3.3/32 area 0.0.0.0`	Advertise loopback address in OSPF
`(config-router)# network 30.30.30.0/24 area 0.0.0.0`	Advertise network address in OSPF
`(config-router)# redistribute connected`	Configure redistribution connected.
`(config-router)#exit`	Exit from Router OSPF mode and enter into config mode
`(config)#commit`	Commit the candidate configuration to the running configuration
`(config)#exit`	Exit from configuration mode

Validation

R1

Before LDP Graceful Restart:

```
RTR1#show running-config ldp
!
router ldp
 graceful-restart full
 graceful-restart timers neighbor-liveness 130
 graceful-restart timers max-recovery 150
!
!
interface ce49
 enable-ldp ipv4
!
RTR1#show ldp session
Peer IP Address           IF Name     My Role     State       KeepAlive  UpTime
```

```
2.2.2.2                 ce49      Passive   OPERATIONAL   30    01:00:10

RTR1#show mpls ldp parameter
Router ID                 : 1.1.1.1
LDP Version               : 1
Global Merge Capability   : Merge Capable
Label Advertisement Mode  : Downstream Unsolicited
Label Retention Mode      : Liberal
Label Control Mode        : Independent
Instance Loop Detection   : Off
Request Retry             : Off
Propagate Release         : Disabled
Graceful Restart          : Enabled
Hello Interval            : 5
Targeted Hello Interval   : 15
Hold time                 : 15
Targeted Hold time        : 45
Keepalive Interval        : 10
Keepalive Timeout         : 30
Request retry Timeout     : 5
Neighbor liveness Time    : 130
Max recovery Time         : 150
Transport Address data    :
  Labelspace 0            : 1.1.1.1 (in use)
Import BGP routes         : No

RTR1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC                 FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32          1         1         -           -     LSP_DEFAULT  3
ce49        No    20.20.20.2
   L>   3.3.3.3/32          2         2         -           -     LSP_DEFAULT  24321
ce49        No    20.20.20.2
   L>   30.30.30.0/24       3         1         -           -     LSP_DEFAULT  3
ce49        No    20.20.20.2
RTR1#

Steps for LDP Graceful Restart:
RTR1#write
Building configuration...
2021 Sep 28 12:54:36.418 : RTR1 : CML : INFO : [CML_5]: Copy-config requested by client
'82'
[OK]
RTR1#restart ldp graceful
```

Validation after Graceful Restart:

```
RTR1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L> p 2.2.2.2/32         1        1         -           -    LSP_DEFAULT  3
ce49        No  p 20.20.20.2
   L> p 3.3.3.3/32         2        2         -           -    LSP_DEFAULT  24321
ce49        No  p 20.20.20.2
   L> p 30.30.30.0/24      3        1         -           -    LSP_DEFAULT  3
ce49        No  p 20.20.20.2
RTR1#show nsm ldp forwarding-timer
Protocol-Name  GR-State  Time Remaining (sec)   Disconnected-time
     LDP        ACTIVE           118           2021/09/28 12:54:47
RTR1#

RTR1#show mpls ftn-table
 Primary FTN entry with FEC: 2.2.2.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: YES, out intf: ce49, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 1, op code: Push


 Primary FTN entry with FEC: 3.3.3.3/32, id: 2, row status: Active, Tunnel-Policy: N/A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
      Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 2, owner: LDP, Stale: YES, out intf: ce49, out label: 24321
    Nexthop addr: 20.20.20.2        cross connect ix: 2, op code: Push


 Primary FTN entry with FEC: 30.30.30.0/24, id: 3, row status: Active, Tunnel-Policy: N/
A
  Owner: LDP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 0, Protected LSP id: 0, Description: N/A, Color: 0
     Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
      Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 1, owner: N/A, Stale: YES, out intf: ce49, out label: 3
    Nexthop addr: 20.20.20.2        cross connect ix: 1, op code: Push
```

```
RTR1#ping 3.3.3.3
Press CTRL+C to exit
PING 3.3.3.3 (3.3.3.3) 56(84) bytes of data.
64 bytes from 3.3.3.3: icmp_seq=1 ttl=64 time=0.540 ms
64 bytes from 3.3.3.3: icmp_seq=2 ttl=64 time=0.539 ms
64 bytes from 3.3.3.3: icmp_seq=3 ttl=64 time=0.491 ms
64 bytes from 3.3.3.3: icmp_seq=4 ttl=64 time=0.501 ms

--- 3.3.3.3 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 69ms
rtt min/avg/max/mdev = 0.491/0.517/0.540/0.035 ms
RTR1#ping 30.30.30.2
Press CTRL+C to exit
PING 30.30.30.2 (30.30.30.2) 56(84) bytes of data.
64 bytes from 30.30.30.2: icmp_seq=1 ttl=64 time=0.519 ms
64 bytes from 30.30.30.2: icmp_seq=2 ttl=64 time=0.540 ms
64 bytes from 30.30.30.2: icmp_seq=3 ttl=64 time=0.549 ms

--- 30.30.30.2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 39ms
rtt min/avg/max/mdev = 0.519/0.536/0.549/0.012 ms
```

ROUTER-2

```
RTR2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
   L> p 1.1.1.1/32         1         1         -           -    LSP_DEFAULT  3
ce0         No  p 20.20.20.1
   L>   3.3.3.3/32         2         2         -           -    LSP_DEFAULT  3
xe13        No    30.30.30.2
RTR2#

After Restarting LDP processes:
root@RTR1:/home/ocnos# cd /usr/local/sbin/
root@RTR1:/usr/local/sbin# ./ldpd -d

RTR1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport
```

```
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   2.2.2.2/32         1         1         -           -     LSP_DEFAULT  3
ce49        No    20.20.20.2
   L>   3.3.3.3/32         2         2         -           -     LSP_DEFAULT  24321
ce49        No    20.20.20.2
   L>   30.30.30.0/24      3         1         -           -     LSP_DEFAULT  3
ce49        No    20.20.20.2
RTR1#

RTR2#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
   L>   1.1.1.1/32         1         1         -           -     LSP_DEFAULT  3
ce0         No    20.20.20.1
   L>   3.3.3.3/32         2         2         -           -     LSP_DEFAULT  3
xe13        No    30.30.30.2
RTR2#
```

CHAPTER 10 LDP Tunneling over RSVP-TE

Overview

LDP-over-RSVP-TE tunneling is a technique used in MPLS networks to combine the strengths of Label Distribution Protocol (LDP) and Resource Reservation Protocol Traffic Engineering (RSVP-TE). This approach allows LDP Label Switched Paths (LSPs) to be encapsulated within RSVP-TE LSPs, providing enhanced traffic engineering capabilities while maintaining operational simplicity.

Feature Characteristics

LDP-over-RSVP-TE facilitates the integration of LDP LSPs within RSVP-TE tunnels, leveraging the strengths of both protocols. It harnesses RSVP-TE's traffic engineering capabilities for path computation, bandwidth reservation, and quality of service (QoS) provisioning. Ingress nodes execute FEC resolution to designate the suitable RSVP-TE tunnel for tunneling LDP LSPs, establishing hierarchical LSPs with RSVP-TE as the outer label and LDP as the inner label.

Benefits

LDP-over-RSVP-TE offers significant benefits are:

- **Advanced Traffic Engineering**: By leveraging RSVP-TE's advanced traffic engineering mechanisms, LDP-over-RSVP-TE enables efficient path computation, bandwidth reservation, and Quality of Service (QoS) provisioning.
- **Simplified Network Topology**: eliminates the need for a full mesh of intra-area RSVP LSPs (Label Switched Paths) between PE (Provider Edge) nodes.
- **Enhanced Resilience with Fast Reroute (FRR)**: Inherit RSVP-TE's Fast Reroute (FRR) capabilities. This means that in case of link or node failures, the network can quickly reroute traffic along pre-established backup paths
- **Flexible Hierarchical LSP Design**: Provides flexibility in network design by allowing for hierarchical LSPs (Label Switched Paths) where RSVP-TE serves as the outer label and LDP as the inner label.

Prerequisites

Before configuring this feature, ensure the following:

- A functional MPLS network with support for both LDP and RSVP-TE protocols.
- Network devices (routers or switches) capable of supporting LDP and RSVP-TE functionalities.

Limitations

The limitations are:

- LDP-over-RSVP tunneling is supported only with ISIS as IGP.
- Tunneling over inter-domain IGP area is not supported.
- LDP LSP tunneling over RSVP multipath is not supported.
- MPLS trace route is not supported in LDP-over-RSVP tunneling path.
- Dynamic TLDP sessions are not supported, TLDP session has to be explicitly configured.

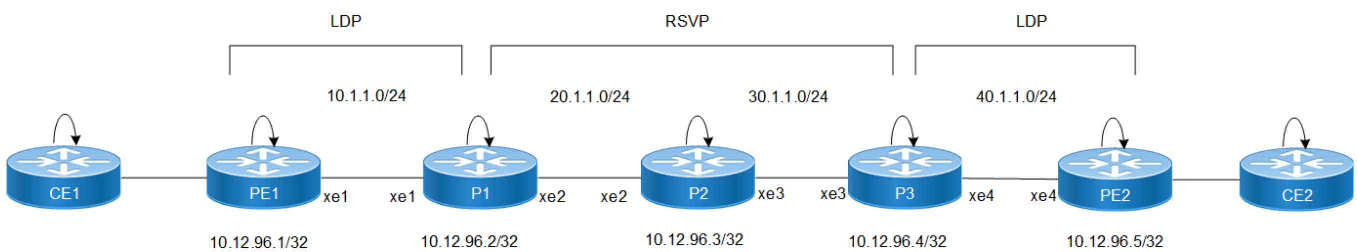
- LFA and/or RLFA protection is not supported for LDP-over-RSVP tunnels.
- MPLS EVPN ELAN services over LoR are not supported.

Configuration for LDP Tunneling Over RSVP

Configure various nodes within the topology to set up a LDP Tunneling over RSVP session.

Topology

This sample topology provides basic connectivity and routing between the devices.



LDP Tunneling over RSVP Configuration

Configure LDP Tunneling over RSVP on PE1 Router

Follow the steps to configure the LDP tunneling over RSVP on PE1 router:

1. Configure the loopback interface with an IP address.
```
PE1(config)#interface lo
PE1(config-if)#ip address 10.12.96.1/32 secondary
```
2. Configure the global LDP parameters including the router ID and transport address.
```
PE1(config)#router ldp
PE1(config-router)#router-id 10.12.96.1
PE1(config-router)#transport-address ipv4 10.12.96.1
```
3. Configure global RSVP parameters.
```
PE1(config)#router rsvp
```
4. Configure the interface facing the network side with an IP address, enable label switching, and enable LDP.
```
PE1(config)#interface xe1
PE1(config-if)#ip address 10.1.1.1/24
PE1(config-if)#label-switching
PE1(config-if)#enable-ldp ipv4
```
5. If using ISIS as the Interior Gateway Protoco (IGP), configure ISIS parameters including traffic engineering.
```
PE1(config)#router isis ISIS-IGP
PE1(config-router)#is-type level-1
PE1(config-router)#metric-style wide
PE1(config-router)#mpls traffic-eng router-id 10.12.96.1
PE1(config-router)#mpls traffic-eng level-1
PE1(config-router)#capability cspf
PE1(config-router)#dynamic-hostname
PE1(config-router)#net 49.0000.0000.0001.00
```

```
PE1(config-router)#exit
```

Configure LDP Tunneling over RSVP on P1 Router

Follow the steps to configure the LDP tunneling over RSVP on P1 router:

1. Configure the loopback interface with an IP address.
```
P1(config)#interface lo
P1(config-if)# ip address 10.12.96.2/32 secondary
```
2. Configure the global TLDP parameters including the router ID and transport address.
```
P1(config)#router ldp
P1(config-router)#router-id 10.12.96.2
P1(config-router)# targeted-peer ipv4 10.12.96.4
P1(config-router-targeted-peer)#exit
P1(config-router)# transport-address ipv4 10.12.96.2
```
3. Configure LDP to prefer tunneling over RSVP.
```
P1(config)#router ldp
P1(config-router)# prefer-tunnel-in-tunnel rsvp
```
4. Configure global RSVP parameters.
```
P1(config)#router rsvp
```
5. Configure a RSVP trunk towards the neighbor router (assuming 10.12.96.4 is the neighbor) and enable ldp-tunneling to allow tunneling LDP LSPs.
```
P1(config)# rsvp-trunk t1 ipv4
P1(config-trunk)#to 10.12.96.4
P1(config-trunk)#ldp-tunneling
```
6. Configure the interface facing the network side with an IP address, enable label switching, and enable LDP and RSVP.
   - For interface xe1:
```
P1(config)#interface xe1
P1(config-if)#ip address 10.1.1.2/24
P1(config-if)#label-switching
P1(config-if)#enable-ldp ipv4
```
   - For interface xe2:
```
P1(config)#interface xe2
P1(config-if)#ip address 20.1.1.1/24
P1(config-if)#label-switching
P1(config-if)#enable-rsvp
```
7. If using ISIS as the Interior Gateway Protoco (IGP), configure ISIS parameters including traffic engineering.
```
P1(config)#router isis ISIS-IGP
P1(config-router)#is-type level-1
P1(config-router)#metric-style wide
P1(config-router)#mpls traffic-eng router-id 10.12.96.2
P1(config-router)#mpls traffic-eng level-1
P1(config-router)#capability cspf
P1(config-router)#dynamic-hostname
P1(config-router)#net 49.0000.0000.0002.00
P1(config-router)#exit
```

Configure LDP Tunneling over RSVP on P2 Router

Follow the steps to configure the LDP tunneling over RSVP on P2 router:

1. Configure the loopback interface with an IP address.

```
P2(config)#interface lo
P2(config-if)# ip address 10.12.96.3/32 secondary
```

2. Configure the global LDP parameters including the router ID and transport address.

```
P2(config)#router ldp
P2(config-router)#router-id 10.12.96.3
P2(config-router)# transport-address ipv4 10.12.96.3
```

3. Configure global RSVP parameters.

```
P2(config)#router rsvp
```

4. Configure the interface facing the network side with an IP address, enable label switching, and enable RSVP.
   - For interface xe2:

```
P2(config)#interface xe2
P2(config-if)#ip address 20.1.1.2/24
P2(config-if)#label-switching
P2(config-if)#enable-rsvp
```

   - For interface xe3:

```
P2(config)#interface xe3
P2(config-if)#ip address 30.1.1.1/24
P2(config-if)#label-switching
P2(config-if)#enable-rsvp
```

5. If using ISIS as the Interior Gateway Protoco (IGP), configure ISIS parameters including traffic engineering.

```
P2(config)#router isis ISIS-IGP
P2(config-router)#is-type level-1
P2(config-router)#metric-style wide
P2(config-router)#mpls traffic-eng router-id 10.12.96.3
P2(config-router)#mpls traffic-eng level-1
P2(config-router)#capability cspf
P2(config-router)#dynamic-hostname
P2(config-router)#net 49.0000.0000.0003.00
P2(config-router)#exit
```

Configure LDP Tunneling over RSVP on P3 Router

Follow the steps to configure the LDP tunneling over RSVP on P3 router:

1. Configure the loopback interface with an IP address.
```
P3(config)#interface lo
P3(config-if)# ip address 10.12.96.4/32 secondary
```
2. Configure the global LDP parameters including the router ID and transport address.
```
P3(config)#router ldp
P3(config-router)#router-id 10.12.96.4
P3(config-router)# targeted-peer ipv4 10.12.96.2
P3(config-router-targeted-peer)#exit
P3(config-router)# transport-address ipv4 10.12.96.4
```
3. Configure global RSVP parameters.
```
P3(config)#router rsvp
```
4. Configure prefix lists.
```
P3(config)# ip prefix-list fec_list
P3(config-ip-prefix-list)# seq 5 permit 10.12.96.5/32
P3(config)# ip prefix-list peer_list
P3(config-ip-prefix-list)# seq 5 permit 10.12.96.2/32
```
5. Configure prefix lists to control label advertisement between peers.
```
P3(config)# router ldp
P3(config-router)# advertise-labels for fec_list to peer_list
```
6. Configure the interface facing the network side with an IP address, enable label switching, and enable RSVP.
   - For interface xe3:
```
P3(config)#interface xe3
P3(config-if)#ip address 30.1.1.2/24
P3(config-if)#label-switching
P3(config-if)#enable-rsvp
```
   - For interface xe4:
```
P3(config)#interface xe4
P3(config-if)#ip address 40.1.1.1/24
P3(config-if)#label-switching
P3(config-if)#enable-ldp ipv4
```
7. If using ISIS as the Interior Gateway Protoco (IGP), configure ISIS parameters including traffic engineering.
```
P3(config)#router isis ISIS-IGP
P3(config-router)#is-type level-1
P3(config-router)#metric-style wide
P3(config-router)#mpls traffic-eng router-id 10.12.96.4
P3(config-router)#mpls traffic-eng level-1
P3(config-router)#capability cspf
P3(config-router)#dynamic-hostname
P3(config-router)#net 49.0000.0000.0004.00
P3(config-router)#exit
```

Configure LDP Tunneling over RSVP on PE2 Router

Follow the steps to configure the LDP tunneling over RSVP on PE2 router:

1. configure the loopback interface with an IP address.
```
PE2(config)#interface lo
PE2(config-if)# ip address 10.12.96.5/32 secondary
```
2. Configure the global LDP parameters including the router ID and transport address.
```
PE2(config)#router ldp
PE2(config-router)#router-id 10.12.96.5
PE2(config-router)# transport-address ipv4 10.12.96.5
```
3. Configure the interface facing the network side with an IP address, enable label switching, and enable LDP.
```
PE2(config)#interface xe4
PE2(config-if)#ip address 40.1.1.2/24
PE2(config-if)#label-switching
PE2(config-if)#enable-ldp ipv4
```
4. If using ISIS as the Interior Gateway Protoco (IGP), configure ISIS parameters including traffic engineering.
```
PE2(config)#router isis ISIS-IGP
PE2(config-router)#is-type level-1
PE2(config-router)#metric-style wide
PE2(config-router)#mpls traffic-eng router-id 10.12.96.5
PE2(config-router)#mpls traffic-eng level-1
PE2(config-router)#capability cspf
PE2(config-router)#dynamic-hostname
PE2(config-router)#net 49.0000.0000.0005.00
PE2(config-router)#exit
```

Snippet Configuration on P1 Router

Follow the steps to configure the LDP tunneling over RSVP on P1 router using snippet:

```
P1#show running-config isis
!
!
router isis ISIS-IGP-100
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id 10.12.96.2
 mpls traffic-eng level-1
 capability cspf
 dynamic-hostname
 net 49.0001.0000.0000.0002.00
!

P1#show running-config ldp
!
router ldp
 router-id 10.12.96.2
 prefer-tunnel-in-tunnel rsvp
 targeted-peer ipv4 10.12.96.4
  exit-targeted-peer-mode
 transport-address ipv4 10.12.96.2
!
```

```
interface xe1
 enable-ldp ipv4


P1#show running-config rsvp
!
router rsvp
!
!
interface xe2
 enable-rsvp
!
!
rsvp-trunk t1 ipv4
 to 10.12.96.4
 ldp-tunneling
!
```

Snippet Configuration on P3 Router

Follow the steps to configure the LDP tunneling over RSVP on P3 router using snippet:

```
P3#show running-config ldp
!
router ldp
 targeted-peer ipv4 10.12.96.2
  exit-targeted-peer-mode
 transport-address ipv4 10.12.96.4
 advertise-labels for fec_list to peer_list
!
interface xe4
 enable-ldp ipv4
!
```

Validation

```
Validation on P1 node:

P1#show ldp session
Codes: m - MD5 password is not set/unset.
       g - GR configuration not set/unset.
       t - TCP MSS not set/unset.
       Session has to be cleared manually

Code  Peer IP Address      IF Name    My Role    State      KeepAlive  UpTime
       10.12.96.1             xe1      Active    OPERATIONAL   30    00:05:42
       10.12.96.4              xe2      Passive   OPERATIONAL   30    00:05:44
P1#
P1#
P1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to 
Secondary
indicates the session is active with local repair at one or more nodes
```

```
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
10.12.96.4     10.12.96.2     5001    2201    PRI   t1-Primary                  UP
00:01:15  1 1 SE     -       25600
Total 1 displayed, Up 1, Down 0.

P1#
P1#
P1#
P1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled
Code    FEC                FTN-ID    Nhlfe-ID  Tunnel-ID   Pri   Out-Label    Out-Intf
ELC       Nexthop          UpTime
  L>   10.12.96.1/32      2       39       -         -    -          -         -
-               00:31:26
                                   38       -          Yes   3            xe1
No        10.1.1.1         -
R(t)>   10.12.96.4/32      1        9        5001        Yes   25600        xe2
No        22.1.1.1         00:01:19
  L>   10.12.96.5/32      3       11       -         -    -          -         -
-               00:01:19
                               10       -         Yes   26244       -         No
10.12.96.4      -
                                                                      (via rsvp tunnel-
id 5001, nhlfe_ix 9, label 25600)
P1#
P1#
P1#
P1#show ldp tunneling

Tunnel Name        : t1
Tunnel Endpoint    : 10.12.96.4/32
Tunnel Cost        : 20
Tunnel Owner       : RSVP
Tunnel Status      : Up

FEC                 Upstream-Peer   In-Label   Out-Label
==========================================================
10.12.96.5/32       10.12.96.1      26242     26244

Total FEC tunneld by t1 : 1

P1#
```

```
P1#
P1#show ldp tunneling-fec
FEC               Tunnel-name                        Tunnel-endpoint     Upstream-Peer   In-
label  Out-label
========================================================================================
===================
10.12.96.5/32     t1                            10.12.96.4/32     10.12.96.1     26242
26244

Total LDP Tunneled FEC : 1
P1#
P1#
P1#
P1#
P1#sh ldp tunneling-tunnels
Tunnel-name                   Tunnel-endpoint     Status    Cost
======================================================================
t1                            10.12.96.4/32       Up        20
```

CLI Commands for LDP Tunneling over RSVP-TE

The LDP Tunneling over RSVP-TE introduces the following configuration commands.

ldp-tunneling

Use this command to enable LDP tunneling over RSVP trunk. When a specific RSVP trunk is enabled for tunneling, user traffic is tunneled using LDP LSP over RSVP LSP. If more than one trunk is enabled for tunneling LDP LSP, following trunk selection method is followed:

- If there are more than one trunk with same tunnel end-node, trunk with best metric (lower cost) is selected.
- If a destination FEC is reachable via more than one tunnel-endpoint, a tunnel-endpoint which is closer to destination is selected for tunneling.

Note: TLDP sessions should be manually established with RSVP tunnel end-nodes. Additionally, the 'advertise-labels' CLI must be explicitly configured to permit label advertisement over TLDP sessions.

Use `no` parameter of this command to disable tunneling from a trunk.

Command Syntax

```
ldp-tunneling
no ldp-tunneling
```

Parameters

None

Default

Disabled

Command Mode

rsvp-trunk mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to enable LDP tunneling over RSVP trunk:

```
OcNOS#configure terminal
OcNOS(config)#rsvp-trunk t2
OcNOS(config-trunk)#to 4.4.4.4
OcNOS(config-trunk)#ldp-tunneling
OcNOS(config-trunk)#commit
OcNOS(config-trunk)#end
```

prefer-tunnel-in-tunnel rsvp

Use this command for prioritizing RSVP trunk over LDP-LSP for forwarding LDP traffic. By default incoming LDP traffic is forwarded using LDP LSP. However when this CLI is configured and if RSVP trunk has been enabled for tunneling LDP LSP, user data (incoming LDP LSP) is tunneled over RSVP tunnels. If this CLI is not enabled and RSVP trunk has been enabled for tunneling LDP LSP, user data still can be forwarded over RSVP trunk if no LDP LSP exist.

Use `no` parameter of this command to prioritizing LDP-LSP over RSVP trunk while forwarding LDP traffic.

Command Syntax

```
prefer-tunnel-in-tunnel rsvp
no prefer-tunnel-in-tunnel rsvp
```

Parameters

None

Default

LDP-LSP is selected over RSVP trunks for forwarding.

Command Mode

Router LDP mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to prioritize RSVP trunk over LDP-LSP for forwarding LDP traffic:

```
OcNOS#configure terminal
OcNOS(config)#router ldp
OcNOS(config-router)#prefer-tunnel-in-tunnel rsvp
OcNOS(config-router)#commit
OcNOS(config-router)#end
```

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Show Commands for LDP Over RVSP

show ldp tunneling fec

This command displays the LDP tunneling FEC mappings.

Command Syntax

```
show ldp tunneling-fec
```

Parameters

None

Command Mode

EXEC mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following configuration illustrates how to view the FEC mappings on router R2:

```
R2#show ldp tunneling-fec
FEC                  Tunnel-name                    Tunnel-endpoint
Upstream-Peer   In-label  Out-label
52.1.1.0/24        t2                       4.4.4.4/32        1.1.1.1
26253     26250
53.1.1.0/24        t2                       4.4.4.4/32        1.1.1.1
26255     26241

Total LDP Tunneled FEC : 2
```

show ldp tunneling

This command displays the LDP tunneling.

Command Syntax

```
show ldp tunneling
```

Parameters

None

Command Mode

EXEC mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to view the LDP tunneling on router R2:

```
Tunnel Name        : t1
```

```
Tunnel Endpoint    : 10.12.96.4/32
Tunnel Cost        : 20
Tunnel Owner       : RSVP
Tunnel Status      : Up

FEC                 Upstream-Peer   In-Label   Out-Label
==========================================================
10.12.96.5/32       10.12.96.1      26242     26244

Total FEC tunneld by t1 : 1
```

show ldp tunneling-tunnels.

This command displays the LDP tunneling tunnels.

Command Syntax

```
show ldp tunneling-tunnels
```

Parameters

None

Command Mode

EXEC mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to view the LDP tunneling on router R2:

```
R2#show ldp tunneling-tunnels
Tunnel-name                   Tunnel-endpoint     Status    Cost
t2                            4.4.4.4/32          Up        20
```

Glossary

Note: List key terms used in this document and add the term and explanation to our existing Glossary.

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
Forward Error Correction (FEC)	A system of error control that allows the receiver to correct some errors without having to request a re-transmission of data.
Interior Gateway Protocol (IGP)	An intradomain protocol used to exchange network reachability and routing information among devices within an autonomous system (AS), such as Intermediate System to Intermediate System (IS-IS), Open Shortest Path First (OSPF), or Routing Information Protocol (RIP). Contrast with Exterior Gateway Protocol (EGP).

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Label Distribution Protocol (LDP)	A protocol for distributing labels in non-traffic-engineered applications. LDP allows routers to create label-switched path (LSP) instances through a network by mapping network layer routing information directly to data-link layer switched paths.
Resource Reservation Protocol (RSVP)	A signaling protocol for reserving resources across a network. RSVP is rarely used by itself, but Resource Reservation Protocol—Traffic Engineering (RSVP-TE) is widely used.
Targeted Label Distribution Protocol (TLDP)	A specialized form of LDP (Label Distribution Protocol) sessions.

CHAPTER 11 BGP Auto-Discovery (AD) for LDP VPLS

Overview

The BGP Auto-Discovery enables automatic discovery of VPLS peers, eliminating the need for manual peer configuration. Once discovered, pseudo-wires (PWs) between peers are established using LDP signaling, streamlining the VPLS setup process.

Note: In BGP AD VPLS, if rd and/or router-target is configured in ASN4:nn format while BGP extended ASN support is disabled or vice-versa then BGP auto-discovery will not work and mesh PW will not come up. In such scenarios user is expected to remove the BGP AD VPLS instance and configure it again with correct rd and route-target config as per the BGP extended ASN support.

Benefits

The BGP Auto-Discovery provides in following aspects:

- Simplifies the VPLS configuration process.
- Enhances network scalability.
- Improves scaling efficiency when used with route reflectors.

Prerequisites

- **Define Interfaces and Loopback Addresses:**

  Configure Layer 2 interfaces, such as port channel interfaces (e.g., po1), and assign IP addresses for identification and routing. Additionally, configure loopback IP addresses to establish key connectivity points. These settings ensure efficient network routing and communication.

```
!
interface lo
 ip address 127.0.0.1/8
 ip address 2.2.2.2/32 secondary
 ipv6 address ::1/128

interface xe14
 ip address 30.1.1.2/24
```

- **Configure IGP for Dynamic Routing:**

  Enable ISIS to facilitate dynamic routing on all nodes within the net-work. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution.Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

  - **ISIS Configuration:**

```
router isis 1
 is-type level-2-only
 metric-style wide
 microloop-avoidance level-2
```

```
 mpls traffic-eng router-id 2.2.2.2
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 bfd all-interfaces
 net 49.0000.0000.0002.00
 passive-interface lo
!
interface xe14
 mpls ldp-igp sync isis level-2
 isis network point-to-point
 ip router isis 1
```

- **OSPF Configuration:**

```
router ospf 1
ospf router-id 2.2.2.2
network 2.2.2.2/32 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0!
!
interface xe14
ip ospf network point-to-point
```

- LDP Configuration:

```
router ldp
 router-id 100.1.1.1
 transport-address ipv4 100.1.1.1
```

- BGP Configuration:

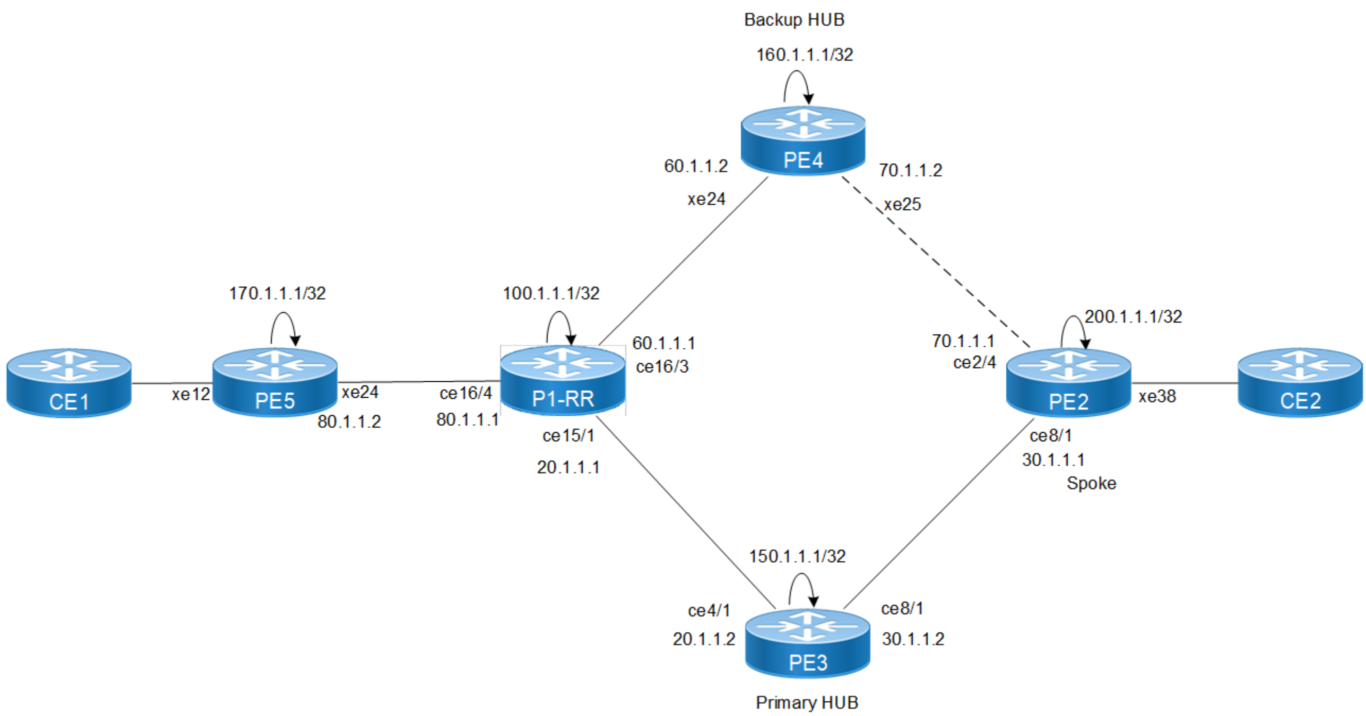
```
!
router bgp 64000
 bgp router-id 100.1.1.1
 neighbor BGP-AD peer-group
 neighbor BGP-AD remote-as 64000
 neighbor BGP-AD update-source lo
 neighbor BGP-AD fall-over bfd multihop
 neighbor 150.1.1.1 peer-group BGP-AD
 neighbor 160.1.1.1 peer-group BGP-AD
 neighbor 170.1.1.1 peer-group BGP-AD
 !
 address-family ipv4 unicast
 redistribute connected
 neighbor BGP-AD activate
 exit-address-family
 !
 address-family l2vpn vpls
 neighbor BGP-AD activate
 neighbor BGP-AD route-reflector-client
 exit-address-family
 !
 exit
!
```

Configuration

Configure various nodes within the topology to set up a H-VPLS session.

Topology

This sample topology provides basic connectivity and routing between the devices.



BGP-A-D LDP VPLS Topology Diagram

Configuring BGP-A-D LDP VPLS

Configure PE5 router as follows:

1. Configure router LDP.

```
PE5(config)#router ldp
PE5(config-router)# router-id 170.1.1.1
PE5(config-router)# transport-address ipv4 170.1.1.1
PE5(config-router)# pw-status-tlv
```

2. Configure loopback interface.

```
PE5(config)#interface lo
PE5(config-af)#ip address 170.1.1.1/32 secondary
```

3. Enable LDP and label-switching for core interface.

```
PE5(config)#interface xe24
PE5(config-if)#ip address 80.1.1.2/24
PE5(config-if)#label-switching
PE5(config-if)#mpls ldp-igp sync ospf
```

```
PE5(config-if)#ip ospf network point-to-point
PE5(config-if)#enable-ldp ipv4

PE5(config-if)#router ospf 100
PE5(config-if)#network 80.1.1.0/24 area 0.0.0.0
PE5(config-if)#network 170.1.1.1/32 area 0.0.0.0
```

4. Configure BGP.

```
PE5(config)#router bgp 64000
PE5(config-router)#bgp router-id 170.1.1.1
PE5(config-router)#neighbor BGP-AD peer-group
PE5(config-router)#neighbor BGP-AD remote-as 64000
PE5(config-router)#neighbor BGP-AD update-source lo
PE5(config-router)#neighbor BGP-AD fall-over bfd multihop
PE5(config-router)#neighbor 100.1.1.1 peer-group BGP-AD
PE5(config-router)#address-family l2vpn vpls
PE5(config-router-af)#neighbor BGP-AD activate
PE5(config-router-af)#exit-address-family
PE5(config-router)#exit
```

5. Configure VPLS instance.

```
PE5(config)#mpls vpls vpls2 2
PE5(config-vpls)#signaling ldp
PE5(config-vpls-sig)#bgp-auto-discovery
PE5(config-vpls-ldp-sig-bgp-ad)#l2vpn-id 200:1001
PE5(config-vpls-ldp-sig-bgp-ad)#rd 10.10.10.10:1001
PE5(config-vpls-ldp-sig-bgp-ad)#route-target both 2:100
PE5(config-vpls-ldp-sig-bgp-ad)#exit-bgp-auto-discovery
PE5(config-vpls-sig)#exit-signaling
PE5(config-vpls)#exit-vpls
```

6. Configure sub-interface and attach vpls-instance to sub-interface.

```
PE5(config)#interface xe12.2 switchport
PE5(config-if)#encapsulation dot1q 2
PE5(config-if)#access-if-vpls
PE5(config-acc-if-vpls)#mpls-vpls vpls2
PE5(config-acc-if-vpls)#exit
PE5(config-if)#exit
```

Configure P1 router as follows:

1. Configure router LDP.

```
P1(config)#router ldp
P1(config-router)#router-id 100.1.1.1
P1(config-router)#transport-address ipv4 100.1.1.1
```

2. Enable LDP and label-switching for core interface.

```
P1(config)#interface ce15/1
P1(config-if)#ip address 20.1.1.1/24
P1(config-if)#label-switching
P1(config-if)#mpls ldp-igp sync ospf
P1(config-if)#ip ospf network point-to-point
P1(config-if)#enable-ldp ipv4
```

3. Configure network interface.

```
P1(config)#interface ce16/3
P1(config-if)#ip address 60.1.1.1/24
P1(config-if)#label-switching
```

```
P1(config-if)#mpls ldp-igp sync ospf
P1(config-if)#ip ospf network point-to-point
P1(config-if)#enable-ldp ipv4

P1(config)#interface ce16/4
P1(config-if)#ip address 80.1.1.1/24
P1(config-if)#label-switching
P1(config-if)#mpls ldp-igp sync ospf
P1(config-if)#ip ospf network point-to-point
P1(config-if)#enable-ldp ipv4
```

4. Configure loopback interface.

```
P1(config)#interface lo
P1(config-if)#ip address 100.1.1.1/32 secondary
```

5. Configure OSPF.

```
P1(config)#router ospf 100
P1(config-router)#network 20.1.1.0/24 area 0.0.0.0
P1(config-router)#network 60.1.1.0/24 area 0.0.0.0
P1(config-router)#network 80.1.1.0/24 area 0.0.0.0
P1(config-router)#network 100.1.1.1/32 area 0.0.0.0
```

6. Configure BGP.

```
P1(config)#router bgp 64000
P1(config-router)#bgp router-id 100.1.1.1
P1(config-router)#neighbor BGP-AD peer-group
P1(config-router)#neighbor BGP-AD remote-as 64000
P1(config-router)#neighbor BGP-AD update-source lo
P1(config-router)#neighbor BGP-AD fall-over bfd multihop
P1(config-router)#neighbor 150.1.1.1 peer-group BGP-AD
P1(config-router)#neighbor 160.1.1.1 peer-group BGP-AD
P1(config-router)#neighbor 170.1.1.1 peer-group BGP-AD
P1(config-router-af)#address-family l2vpn vpls
P1(config-router-af)#neighbor BGP-AD activate
P1(config-router-af)#neighbor BGP-AD route-reflector-client
P1(config-router-af)#exit-address-family
P1(config-router)#exit
```

Configure PE3 router as follows:

1. Configure router LDP.

```
PE3(config)#router ldp
PE3(config-router)# router-id 150.1.1.1
PE3(config-router)# transport-address ipv4 150.1.1.1
```

2. Enable LDP and label-switching for core interface.

```
PE3(config)#interface ce4/1
PE3(config-if)#ip address 20.1.1.2/24
PE3(config-if)#label-switching
PE3(config-if)#mpls ldp-igp sync ospf
PE3(config-if)#ip ospf network point-to-point
PE3(config-if)#enable-ldp ipv4

PE3(config)#interface ce8/1
PE3(config-if)#ip address 30.1.1.2/24
PE3(config-if)#label-switching
PE3(config-if)#mpls ldp-igp sync ospf
```

```
PE3(config-if)#ip ospf network point-to-point
PE3(config-if)#enable-ldp ipv4
```

3. Configure loopback interface.

```
PE3(config)#interface lo
PE3(config-if)#ip address 150.1.1.1/32 secondary
```

4. Configure OSPF.

```
PE3(config)#router ospf 100
PE3(config-router)#network 20.1.1.0/24 area 0.0.0.0
PE3(config-router)#network 30.1.1.0/24 area 0.0.0.0
PE3(config-router)#network 150.1.1.1/32 area 0.0.0.0
```

5. Configure BGP.

```
PE3(config)#router bgp 64000
PE3(config-router)#bgp router-id 150.1.1.1
PE3(config-router)#neighbor BGP-AD peer-group
PE3(config-router)#neighbor BGP-AD remote-as 64000
PE3(config-router)#neighbor BGP-AD update-source lo
PE3(config-router)#neighbor BGP-AD fall-over bfd multihop
PE3(config-router)#neighbor 100.1.1.1 peer-group BGP-AD
PE3(config-router-af)#address-family l2vpn vpls
PE3(config-router-af)#neighbor BGP-AD activate
PE3(config-router-af)#neighbor BGP-AD route-reflector-client
PE3(config-router-af)#exit-address-family
PE3(config-router)#exit
```

6. Configure an MPLS L2 Circuit.

```
PE3(config)#mpls l2-circuit vc1 101 200.1.1.1
```

7. Configure an MPLS VPLS Instance.

```
PE3(config)#mpls vpls vpls2 2
PE3(config-vpls-spoke)#vpls-vc vc1
PE3(config-vpls-spoke)#exit-spoke
PE3(config-vpls)#signaling ldp
PE3(config-vpls-sig)#bgp-auto-discovery
PE3(config-vpls-ldp-sig-bgp-ad)#l2vpn-id 200:1001
PE3(config-vpls-ldp-sig-bgp-ad)#rd 10.10.10.10:1001
PE3(config-vpls-ldp-sig-bgp-ad)#route-target both 2:100
PE3(config-vpls-ldp-sig-bgp-ad)#exit-bgp-auto-discovery
PE3(config-vpls-sig)#exit-signaling
PE3(config-vpls)#exit-vpls
```

8. Configure the network Interface.

```
PE3(config)#interface ce4/2.2 switchport
PE3(config-if)#encapsulation dot1q 2
PE3(config-if)#access-if-vpls
PE3(config-acc-if-vpls)#mpls-vpls vpls2
PE3(config-acc-if-vpls)#exit
PE3(config-if)#exit
```

Configure PE4 router as follows:

1. Configure router LDP.

```
PE4(config)#router ldp
PE4(config-router)# router-id 160.1.1.1
PE4(config-router)# transport-address ipv4 160.1.1.1
```

2. Configure loopback interface.

```
PE4(config)#interface lo
PE4(config-if)#ip address 160.1.1.1/32 secondary
```

3. Enable LDP and label-switching for core interface.

```
PE4(config)#interface xe24
PE4(config-if)#ip address 60.1.1.2/24
PE4(config-if)#label-switching
PE4(config-if)#mpls ldp-igp sync ospf
PE4(config-if)#ip ospf network point-to-point
PE4(config-if)#enable-ldp ipv4

PE4(config)#interface xe25
PE4(config-if)#ip address 70.1.1.2/24
PE4(config-if)#label-switching
PE4(config-if)#mpls ldp-igp sync ospf
PE4(config-if)#ip ospf network point-to-point
PE4(config-if)#enable-ldp ipv4
```

4. Configure OSPF.

```
PE4(config)#router ospf 100
PE4(config-router)#network 60.1.1.0/24 area 0.0.0.0
PE4(config-router)#network 70.1.1.0/24 area 0.0.0.0
PE4(config-router)#network 160.1.1.1/32 area 0.0.0.0
```

5. Configure BGP.

```
PE4(config)#router bgp 64000
PE4(config-router)#bgp router-id 160.1.1.1
PE4(config-router)#neighbor BGP-AD peer-group
PE4(config-router)#neighbor BGP-AD remote-as 64000
PE4(config-router)#neighbor BGP-AD update-source lo
PE4(config-router)#neighbor BGP-AD fall-over bfd multihop
PE4(config-router)#neighbor 100.1.1.1 peer-group BGP-AD
PE4(config-router-af)#address-family l2vpn vpls
PE4(config-router-af)#neighbor BGP-AD activate
PE4(config-router-af)#exit-address-family
PE4(config-router)#exit
```

6. Configure an MPLS L2 Circuit.

```
PE4(config)#mpls l2-circuit vc1001 1101 200.1.1.1
```

7. Configure an MPLS VPLS Instance.

```
PE4(config)#mpls vpls vpls2 2
PE4(config-vpls-spoke)#vpls-vc vc1001
PE4(config-vpls-spoke)#exit-spoke
PE4(config-vpls)#signaling ldp
PE4(config-vpls-sig)#bgp-auto-discovery
PE4(config-vpls-ldp-sig-bgp-ad)#l2vpn-id 200:1001
PE4(config-vpls-ldp-sig-bgp-ad)#rd 10.10.10.10:1001
PE4(config-vpls-ldp-sig-bgp-ad)#route-target both 2:100
PE4(config-vpls-ldp-sig-bgp-ad)#exit-bgp-auto-discovery
PE4(config-vpls-sig)#exit-signaling
PE4(config-vpls)#exit-vpls
```

8. Configure the network Interface.

```
PE4(config)#interface xe12.2 switchport
PE4(config-if)#encapsulation dot1q 2
PE4(config-if)#access-if-vpls
PE4(config-acc-if-vpls)#mpls-vpls vpls2
```

```
PE4(config-acc-if-vpls)#exit
PE4(config-if)#exit
```

Configure PE2 router as follows:

1. Configure router LDP.
```
PE4(config)#router ldp
PE4(config-router)# router-id 200.1.1.1
PE4(config-router)# transport-address ipv4 200.1.1.1
```
2. Enable LDP and label-switching for core interface.
```
PE4(config)#interface ce2/4
PE4(config-if)#ip address 70.1.1.2/24
PE4(config-if)#label-switching
PE4(config-if)#mpls ldp-igp sync ospf
PE4(config-if)#ip ospf network point-to-point
PE4(config-if)#enable-ldp ipv4

PE4(config)#interface ce8/1
PE4(config-if)#ip address 30.1.1.2/24
PE4(config-if)#label-switching
PE4(config-if)#mpls ldp-igp sync ospf
PE4(config-if)#ip ospf network point-to-point
PE4(config-if)#enable-ldp ipv4
```
3. Configure loopback interface.
```
PE4(config)#interface lo
PE4(config-if)#ip address 200.1.1.1/32 secondary
```
4. Enable LDP and label-switching for core interface.
```
PE4(config)#interface xe42
PE4(config-if)#ip address 10.1.1.2/24
PE4(config-if)#label-switching
PE4(config-if)#mpls ldp-igp sync ospf
PE4(config-if)#ip ospf network point-to-point
PE4(config-if)#enable-ldp ipv4
```
5. Configure OSPF.
```
PE4(config)#router ospf 100
PE4(config-router)#network 10.1.1.0/24 area 0.0.0.0
PE4(config-router)#network 30.1.1.0/24 area 0.0.0.0
PE4(config-router)#network 70.1.1.1/24 area 0.0.0.0
PE4(config-router)#network 200.1.1.1/32 area 0.0.0.0
```
6. Configure an MPLS L2 Circuit.
```
PE4(config)#mpls l2-circuit vc1 101 150.1.1.1
PE4(config)#mpls l2-circuit vc1001 1101 160.1.1.1
```
7. Configure an MPLS VPLS Instance.
```
PE4(config)#mpls vpls vpls2 2
PE4(config-vpls)#vpls-vc vc1
PE4(config-vpls-spoke)#vpls-vc secondary vc100
PE4(config-vpls-spoke)#exit-spoke
PE4(config-vpls)#exit-vpls
```
8. Configure the network Interface.
```
PE4(config)#interface xe38.2 switchport
PE4(config-if)#encapsulation dot1q 2
```

```
PE4(config-if)#access-if-vpls
PE4(config-acc-if-vpls)#mpls-vpls vpls2
PE4(config-acc-if-vpls)#exit
PE4(config-if)#exit
```

Running Configuration on PE1 Router:

LDP:

```
router ldp
 router-id 2.2.2.2
 pw-status-tlv
 transport-address ipv4 2.2.2.2
!
!
interface xe14
     enable-ldp ipv4
!
```

VPLS:

```
mpls vpls vpls2000 2000
signaling ldp
  bgp-auto-discovery
    rd 100.200.100.200:200
    route-target both 64000:1
    l2vpn-id 64000:2000
    exit-bgp-auto-discovery
        exit-signaling
```

BGP:

```
router bgp 64000
 bgp router-id 2.2.2.2
 neighbor 3.3.3.3 remote-as 64000
 neighbor 5.5.5.5 remote-as 64000
 neighbor 3.3.3.3 update-source lo
 neighbor 5.5.5.5 update-source lo
 !
 address-family l2vpn vpls
 neighbor 3.3.3.3 activate
 neighbor 5.5.5.5 activate
```

Running Configuration on PE2 Router:

```
router ldp
 router-id 200.1.1.1
 transport-address ipv4 200.1.1.1
!
interface ce2/4
 ip address 70.1.1.1/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
```

```
 enable-ldp ipv4
!
interface ce8/1
 ip address 30.1.1.1/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
interface lo
 ip address 127.0.0.1/8
 ip address 200.1.1.1/32 secondary
 ipv6 address ::1/128
!
interface xe42
 ip address 10.1.1.2/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
router ospf 100
 network 10.1.1.0/24 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0
 network 70.1.1.0/24 area 0.0.0.0
 network 200.1.1.1/32 area 0.0.0.0
!
mpls l2-circuit vc1 101 150.1.1.1
!
mpls l2-circuit vc1001 1101 160.1.1.1
!
mpls vpls vpls2 2
 vpls-vc vc1
   secondary vc1001
 exit-spoke
 exit-vpls
!
interface xe38.2 switchport
 encapsulation dot1q 2
  access-if-vpls
    mpls-vpls vpls2
  exit
 exit
!
```

Running Configuration on PE3 Router:

```
router ldp
 router-id 150.1.1.1
 transport-address ipv4 150.1.1.1
!
interface ce4/1
 ip address 20.1.1.2/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
```

```
 enable-ldp ipv4
!
interface ce8/1
 ip address 30.1.1.2/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
interface lo
 ip address 127.0.0.1/8
 ip address 150.1.1.1/32 secondary
 ipv6 address ::1/128
!
router ospf 100
 network 20.1.1.0/24 area 0.0.0.0
 network 30.1.1.0/24 area 0.0.0.0
 network 150.1.1.1/32 area 0.0.0.0
!
router bgp 64000
 bgp router-id 150.1.1.1
 neighbor BGP-AD peer-group
 neighbor BGP-AD remote-as 64000
 neighbor BGP-AD update-source lo
 neighbor BGP-AD fall-over bfd multihop
 neighbor 100.1.1.1 peer-group BGP-AD
 !
 address-family ipv4 unicast
 redistribute connected
 neighbor BGP-AD activate
 exit-address-family
 !
 address-family l2vpn vpls
 neighbor BGP-AD activate
 exit-address-family
 !
 exit
!
mpls l2-circuit vc1 101 200.1.1.1
!
mpls vpls vpls2 2
 vpls-vc vc1
 exit-spoke
 signaling ldp
  bgp-auto-discovery
    l2vpn-id 200:1001
    rd 10.10.10.10:1001
    route-target both 2:100
    exit-bgp-auto-discovery
  exit-signaling
 exit-vpls
!
interface ce4/2.2 switchport
 encapsulation dot1q 2
  access-if-vpls
    mpls-vpls vpls2
  exit
```

```
 exit
!
end
```

Running Configuration on P1 Router:

```
router ldp
 router-id 100.1.1.1
 transport-address ipv4 100.1.1.1
!
interface ce15/1
 ip address 20.1.1.1/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
interface ce16/3
 ip address 60.1.1.1/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
interface ce16/4
 ip address 80.1.1.1/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
interface lo
 ip address 127.0.0.1/8
 ip address 100.1.1.1/32 secondary
 ipv6 address ::1/128
!
router ospf 100
 network 20.1.1.0/24 area 0.0.0.0
 network 60.1.1.0/24 area 0.0.0.0
 network 80.1.1.0/24 area 0.0.0.0
 network 100.1.1.1/32 area 0.0.0.0
!
router bgp 64000
 bgp router-id 100.1.1.1
 neighbor BGP-AD peer-group
 neighbor BGP-AD remote-as 64000
 neighbor BGP-AD update-source lo
 neighbor BGP-AD fall-over bfd multihop
 neighbor 150.1.1.1 peer-group BGP-AD
 neighbor 160.1.1.1 peer-group BGP-AD
 neighbor 170.1.1.1 peer-group BGP-AD
 !
 address-family ipv4 unicast
 redistribute connected
 neighbor BGP-AD activate
 exit-address-family
```

```
 !
 address-family l2vpn vpls
 neighbor BGP-AD activate
 neighbor BGP-AD route-reflector-client
 exit-address-family
 !
 exit
!
```

Running Configuration on PE4 Router:

```
router ldp
 router-id 160.1.1.1
 transport-address ipv4 160.1.1.1
!
interface lo
 ip address 127.0.0.1/8
 ip address 160.1.1.1/32 secondary
 ipv6 address ::1/128
!
interface xe24
 ip address 60.1.1.2/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
interface xe25
 ip address 70.1.1.2/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
router ospf 100
 network 60.1.1.0/24 area 0.0.0.0
 network 70.1.1.0/24 area 0.0.0.0
 network 160.1.1.1/32 area 0.0.0.0
!
router bgp 64000
 bgp router-id 160.1.1.1
 neighbor BGP-AD peer-group
 neighbor BGP-AD remote-as 64000
 neighbor BGP-AD update-source lo
 neighbor BGP-AD fall-over bfd multihop
 neighbor 100.1.1.1 peer-group BGP-AD
 !
 address-family ipv4 unicast
 redistribute connected
 neighbor BGP-AD activate
 exit-address-family
 !
 address-family l2vpn vpls
 neighbor BGP-AD activate
 exit-address-family
 !
```

```
 exit
!
mpls l2-circuit vc1001 1101 200.1.1.1
!
mpls vpls vpls2 2
 vpls-vc vc1001
 exit-spoke
 signaling ldp
  bgp-auto-discovery
    l2vpn-id 200:1001
    rd 10.10.10.10:1001
    route-target both 2:100
    exit-bgp-auto-discovery
  exit-signaling
 exit-vpls
!
interface xe12.2 switchport
 encapsulation dot1q 2
  access-if-vpls
    mpls-vpls vpls2
  exit
 exit
!
end
```

Running Configuration on PE5 Router:

```
router ldp
 router-id 170.1.1.1
 transport-address ipv4 170.1.1.1
!
interface lo
 ip address 127.0.0.1/8
 ip address 170.1.1.1/32 secondary
 ipv6 address ::1/128
!
interface xe24
 ip address 80.1.1.2/24
 label-switching
 mpls ldp-igp sync ospf
 ip ospf network point-to-point
 enable-ldp ipv4
!
router ospf 100
 network 80.1.1.0/24 area 0.0.0.0
 network 170.1.1.1/32 area 0.0.0.0
!
router bgp 64000
 bgp router-id 170.1.1.1
 neighbor BGP-AD peer-group
 neighbor BGP-AD remote-as 64000
 neighbor BGP-AD update-source lo
 neighbor BGP-AD fall-over bfd multihop
 neighbor 100.1.1.1 peer-group BGP-AD
 !
 address-family ipv4 unicast
```

```
     redistribute connected
     neighbor BGP-AD activate
     exit-address-family
     !
     address-family l2vpn vpls
     neighbor BGP-AD activate
     exit-address-family
     !
     exit
    !
    mpls vpls vpls2 2
     signaling ldp
      bgp-auto-discovery
        l2vpn-id 200:1001
        rd 10.10.10.10:1001
        route-target both 2:100
        exit-bgp-auto-discovery
      exit-signaling
     exit-vpls
    !
    interface xe12.2 switchport
     encapsulation dot1q 2
      access-if-vpls
        mpls-vpls vpls2
      exit
     exit
    !
```

Validation

Validate the show output after configuration as shown below.

```
PE3-Pri-HUB#sh mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status      UpTime     Ext-Color
2         160.1.1.1        24322        26241      ce4/1          26241      2/Up
0        LDP            Active     00:02:28      -
2         170.1.1.1        25612        26242      ce4/1          26240      2/Up
0        LDP            Active     00:00:31      -
9600-PE3-Pri-HUB#
9600-PE3-Pri-HUB#
9600-PE3-Pri-HUB#sh mpls vpls detail
Virtual Private LAN Service Instance: vpls2, ID: 2
 SIG-Protocol: LDP
  Route-Distinguisher :10.10.10.10:1001
  Route-Target :2:100
  L2 VPN ID :200:1001
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
```

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```
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 9000
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 MAC Withdrawal:

 Configured interfaces:
  Interface: ce4/2.2
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2

 Mesh Peers:
   160.1.1.1 (Type: Ethernet VLAN) (Negotiated - CW: No, FAT: No) (Up) (UpTime: 
00:02:55)
    FEC signaling element: FEC129
    FEC129 details:
      agi : 00 0A 00 C8 00 00 03 E9
      saii: 150.1.1.1
      taii: 160.1.1.1

   170.1.1.1 (Type: Ethernet VLAN) (Negotiated - CW: No, FAT: No) (Up) (UpTime: 
00:00:58)
    FEC signaling element: FEC129
    FEC129 details:
      agi : 00 0A 00 C8 00 00 03 E9
      saii: 150.1.1.1
      taii: 170.1.1.1

 Spoke Peers:
   vc1 (Up) (UpTime 00:03:28)


9600-PE3-Pri-HUB#sh bgp l2vpn vpls ldp-sig
VPLS-ID     Discovered-Peers  Route-Distinguisher    L2VPN-ID
2           2                 10.10.10.10:1001       200:1001
9600-PE3-Pri-HUB#sh bgp l2vpn vpls ldp-sig detail
VPLS-ID: 2
Local L2VPN-ID      : 200:1001
Local RD            : 10.10.10.10:1001
Local Route-Targets :
    Import List     : 2:100
    Export List     : 2:100
Discovered Peers    : 2
Mesh Peers          :
    BGP Peer-1      : 100.1.1.1
      Peer L2VPN-ID       : 200:1001
      Peer Route-Targets  :
        Export List       : 2:100
```

```
      Peer Up time        : 00:02:03

    BGP Peer-2      : 100.1.1.1
      Peer L2VPN-ID       : 200:1001
      Peer Route-Targets  :
        Export List       : 2:100
      Peer Up time        : 00:04:10


9600-PE3-Pri-HUB#
-----------------------------------------------------------------------------------------
-------------------------------------------

7535-6-PE4-Bkp-HUB#sh mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP

VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status     UpTime     Ext-Color
2          150.1.1.1         24325         26241      xe24           26241      2/Up
0         LDP            Active     00:02:33      -
2          170.1.1.1         25614         26242      xe24           26241      2/Up
0         LDP            Active     00:00:36      -
7535-6-PE4-Bkp-HUB#
7535-6-PE4-Bkp-HUB#
7535-6-PE4-Bkp-HUB#sh mpls vpls detail
Virtual Private LAN Service Instance: vpls2, ID: 2
 SIG-Protocol: LDP
  Route-Distinguisher :10.10.10.10:1001
  Route-Target :2:100
  L2 VPN ID :200:1001
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 9000
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 MAC Withdrawal:

 Configured interfaces:
  Interface: xe12.2
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2

 Mesh Peers:
```

```
   150.1.1.1 (Type: Ethernet VLAN) (Negotiated - CW: No, FAT: No) (Up) (UpTime:
00:03:00)
    FEC signaling element: FEC129
    FEC129 details:
      agi : 00 0A 00 C8 00 00 03 E9
      saii: 160.1.1.1
      taii: 150.1.1.1

   170.1.1.1 (Type: Ethernet VLAN) (Negotiated - CW: No, FAT: No) (Up) (UpTime:
00:01:03)
    FEC signaling element: FEC129
    FEC129 details:
      agi : 00 0A 00 C8 00 00 03 E9
      saii: 160.1.1.1
      taii: 170.1.1.1

 Spoke Peers:
   vc1001 (Dn) (Reason: VC on standby)


7535-6-PE4-Bkp-HUB# sh bgp l2vpn vpls ldp-sig
VPLS-ID     Discovered-Peers  Route-Distinguisher    L2VPN-ID
2           2                 10.10.10.10:1001       200:1001
7535-6-PE4-Bkp-HUB#sh bgp l2vpn vpls ldp-sig detail
VPLS-ID: 2
Local L2VPN-ID      : 200:1001
Local RD            : 10.10.10.10:1001
Local Route-Targets :
    Import List     : 2:100
    Export List     : 2:100
Discovered Peers    : 2
Mesh Peers          :
    BGP Peer-1      : 100.1.1.1
      Peer L2VPN-ID       : 200:1001
      Peer Route-Targets  :
        Export List       : 2:100
      Peer Up time        : 00:02:14

    BGP Peer-2      : 100.1.1.1
      Peer L2VPN-ID       : 200:1001
      Peer Route-Targets  :
        Export List       : 2:100
      Peer Up time        : 00:04:25


-----------------------------------------------------------------------------------------
------------------------------------------
7535-7-PE5#sh mpls vpls mesh
(m) - Service mapped over multipath transport
(e) - Service mapped over LDP ECMP
```

```
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label  Lkps/St
PW-INDEX SIG-Protocol   Status      UpTime     Ext-Color
2          150.1.1.1        25618         26240      xe24           26242      2/Up
0         LDP           Active     00:00:08      -
2          160.1.1.1        25619         26241      xe24           26242      2/Up
0         LDP           Active     00:00:08      -
7535-7-PE5#
7535-7-PE5#
7535-7-PE5#
7535-7-PE5#sh mpls vpls detail
Virtual Private LAN Service Instance: vpls2, ID: 2
 SIG-Protocol: LDP
  Route-Distinguisher :10.10.10.10:1001
  Route-Target :2:100
  L2 VPN ID :200:1001
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 9000
 Description: none
 service-tpid: dot1.q
 Operating mode: Tagged
 Svlan Id: 0
 Svlan Tpid: 8100
 MAC Withdrawal:

 Configured interfaces:
  Interface: xe12.2
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2

 Mesh Peers:
   150.1.1.1 (Type: Ethernet VLAN) (Negotiated - CW: No, FAT: No) (Up) (UpTime:
00:00:26)
    FEC signaling element: FEC129
    FEC129 details:
      agi : 00 0A 00 C8 00 00 03 E9
      saii: 170.1.1.1
      taii: 150.1.1.1

   160.1.1.1 (Type: Ethernet VLAN) (Negotiated - CW: No, FAT: No) (Up) (UpTime:
00:00:26)
    FEC signaling element: FEC129
    FEC129 details:
      agi : 00 0A 00 C8 00 00 03 E9
      saii: 170.1.1.1
      taii: 160.1.1.1
```

```
7535-7-PE5#sh bgp l2vpn vpls ldp-sig
VPLS-ID     Discovered-Peers  Route-Distinguisher    L2VPN-ID
2           2                 10.10.10.10:1001       200:1001
7535-7-PE5#sh bgp l2vpn vpls ldp-sig detail
VPLS-ID: 2
Local L2VPN-ID      : 200:1001
Local RD            : 10.10.10.10:1001
Local Route-Targets :
    Import List     : 2:100
    Export List     : 2:100
Discovered Peers    : 2
Mesh Peers          :
    BGP Peer-1      : 100.1.1.1
      Peer L2VPN-ID       : 200:1001
      Peer Route-Targets  :
        Export List       : 2:100
      Peer Up time        : 00:02:30

    BGP Peer-2      : 100.1.1.1
      Peer L2VPN-ID       : 200:1001
      Peer Route-Targets  :
        Export List       : 2:100
      Peer Up time        : 00:02:30

-----------------------------------------------------------------------------------------
------------------------------------------
7946-74-PE2-SPOKE#sh mpls vpls detail
Virtual Private LAN Service Instance: vpls2, ID: 2
 SIG-Protocol: N/A
 Attachment-Circuit: UP
 Learning: Enabled
 Control-Word: Disabled
 Flow Label Status: Disabled, Direction: None, Static: No
 Group ID: 0, Configured MTU: 9000
 Description: none
 service-tpid: dot1.q
 Operating mode: Raw
 MAC Withdrawal:

 Configured interfaces:
  Interface: xe38.2
   Status: Up
   Subinterface Match Criteria(s) :
   dot1q 2

 Spoke Peers:
   vc1 (Up) (UpTime 00:04:18)
    Secondary: vc1001 (Dn) (Reason: VC on standby)
```

```
7946-74-PE2-SPOKE#sh run vpls
!
mpls vpls vpls2 2
 vpls-mtu 9000
 vpls-vc vc1
  secondary vc1001
  exit-spoke
 exit-vpls
!
!
interface xe38.2 switchport
 access-if-vpls
  mpls-vpls vpls2
!
7946-74-PE2-SPOKE#sh mpls vpls spoke
VPLS-ID    Peer Addr    Virtual Circuit  Tunnel-Label In-Label   Network-Intf   Out-
Label  Lkps/St   Secondary
2         150.1.1.1    vc1             0            26240      ce8/1          26240
2/Up     vc1001
2         160.1.1.1    vc1001          N/A          26241      N/A            26240
0/Dn     ---
7946-74-PE2-SPOKE#
```

CLI Commands

The BGP Auto-Discovery (AD) introduces the following configuration commands.

bgp-auto-discovery

Use this command to enable BGP Auto-Discovery for LDP peers.

Use `no` parameter of this command to disable BGP Auto-Discovery for LDP peers.

Command Syntax

```
bgp-auto-discovery
no bgp-auto-discovery
```

Parameters

None

Default

Disabled

Command Mode

SIGNALING LDP mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

Explain or describe the example.

```
#configure terminal
(config)#mpls vpls VPLS100 100
(config-vpls)#signaling ldp
(config-vpls-sig)#bgp-auto-discovery
(config-vpls-ldp-sig-bgp-ad)#exit-bgp-auto-discovery
(config-vpls-sig)#exit
(config-vpls)#exit
```

l2vpn-id

Use this command to assign a Layer 2 VPN ID for the LDP VPLS.

Use `no` form command to remove the Layer 2 VPN ID configuration.

Command Syntax

```
l2vpn-id  ASN:nn_or_IP-address:nn
no l2vpn-id  ASN:nn_or_IP-address:nn
```

Parameters

`ASN:nn_or_IP-address:nn`
: AS number and an arbitrary number (for example, 100:1). Otherwise, specify a 32-bit IP address and an arbitrary number (for example, 192.16.10.1:1).

Default

The default value is set to ASN:VPLS ID when BGP external ASN support is disabled and the BGP ASN is less than 65535; otherwise, specifying a value is mandatory.

Command Mode

BGP AUTO DISCOVERY mode

Applicability

This command is introduced in OcNOS version 6.0.0.

Examples

```
#configure terminal
(config)#mpls vpls VPLS100 100
(config-vpls)#signaling ldp
(config-vpls-sig)#bgp-auto-discovery
(config-vpls-ldp-sig-bgp-ad)#l2vpn-id 3.3.3.3:3333
(config-vpls-ldp-sig-bgp-ad)#exit-bgp-auto-discovery
(config-vpls-sig)#exit
(config-vpls)#exit
```

rd (route distinguisher)

Use this command to assign a route distinguisher (RD) for the BGP AD VPLS. The route distinguisher value must be unique within all BGP AD VPLS instances on the router.

Note: BGP auto-discovery requires an RD configuration. Once configured, the RD can be modified but not removed individually; you must remove the entire bgp-auto-discovery configuration block.

Command Syntax

```
rd ASN:nn_or_IP-address:nn
```

Parameters

`ASN:nn_or_IP-address:nn`

AS number and an arbitrary number (for example, 100:1). Otherwise, specify a 32-bit IP address and an arbitrary number (for example, 192.16.10.1:1).

Default

None

Command Mode

BGP AUTO DISCOVERY mode

Applicability

This command is introduced in OcNOS version 6.0.0.

Examples

```
#configure terminal
(config)#mpls vpls VPLS100 100
(config-vpls)#signaling ldp
(config-vpls-sig)#bgp-auto-discovery
(config-vpls-ldp-sig-bgp-ad)#rd 1.1.1.1:1111
(config-vpls-ldp-sig-bgp-ad)#exit-bgp-auto-discovery
(config-vpls-sig)#exit
(config-vpls)#exit
```

route-target

Use this command to configure a route-target of type both to the BGP AD VPLS.

Note: Only one route-target of type "both" is supported, and once it is configured, it cannot be modified. To change it, the entire bgp-auto-discovery configuration block must be removed.

Command Syntax

```
route-target (both) (ASN:nn_or_IP-address:nn|)
```

Parameters

`both` Import and export routing information

`ASN:nn_or_IP-address:nn`
: AS number and an arbitrary number (for example, 100:1). Otherwise, specify a 32-bit IP address and an arbitrary number (for example, 192.16.10.1:1).

Default

None

Command Mode

BGP AUTO DISCOVERY mode

Applicability

This command is introduced in OcNOS version 6.0.0.

Examples

```
#configure terminal
(config)#mpls vpls VPLS100 100
(config-vpls)#signaling ldp
(config-vpls-sig)#bgp-auto-discovery
(config-vpls-ldp-sig-bgp-ad)#route-target both 2.2.2.2:2222
(config-vpls-ldp-sig-bgp-ad)#exit-bgp-auto-discovery
(config-vpls-sig)#exit
(config-vpls)#exit
```

Label Distribution Protocol Command Reference

CHAPTER 1 LDP Commands

This chapter is a reference for the LDP commands:

advertise-labels

Use this command to prevent the distribution of any locally assigned labels.

Use the `no` parameter to enable the distribution of all locally assigned labels to all LDP neighbors.

Command Syntax

```
advertise-labels for any to none
advertise-labels for PREFIX to (PEER|any)
no advertise-labels for any to none
no advertise-labels for PREFIX to (PEER|any)
```

Parameters

`for`	Specify the permitted destinations
`any`	Specify to permit any locally assigned labels
`PREFIX`	Specify the destinations which have labels are advertised
`to`	Specify the given neighbor
`PEER`	Specify the LDP neighbors which receive these advertisements
`none`	Specify that there are no LDP neighbors

Default

The labels of all destinations are advertised to all LDP neighbors.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#advertise-labels for any to none

#configure terminal
(config)#router ldp
(config-router)#advertise-labels for PREFIX to any

#configure terminal
(config)#router ldp
(config-router)#advertise-labels for PREFIX to PEER
```

advertise-label-for-default-route

Use this command to enable label advertisement for default route.

Use `no` form to disable the label advertisement for default route.

Command Syntax

```
advertise-label-for-default-route
```

Parameters

None

Default

Disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#advertise-label-for-default-route
```

advertisement-mode

Use this command to set the label advertisement mode for all the interfaces for the current LSR. Specifying `downstream-on-demand` and `downstream-unsolicited` mode affects which LSR initiates mapping requests and mapping advertisements.

This command is a global command used to set the label advertisement mode for all interfaces for the current LSR. The advertisement mode set for a specific interface overrides the value set by this command (see ldp advertisement-mode). Use this command before starting the interface as it closes and restarts all sessions.

Use the `no` parameter to revert to the default advertisement mode value.

Command Syntax

```
advertisement-mode (downstream-on-demand|downstream-unsolicited)
no advertisement-mode (downstream-on-demand|downstream-unsolicited)
```

Parameters

`downstream-on-demand`

Sends label upon request. When a users uses this mode, a router distributes a label to a peer only if there is a pending label request from a peer. The reaction of the downstream router to this request depends on the label advertising mode supported on the next hop. This mode is typically used with the conservative label retention mode.

`downstream-unsolicited`

Sends label without waiting request. This mode distributes labels to peers without waiting for a label request, and is typically used with the liberal label retention mode.

Default

By default, advertisement mode is downstream-unsolicited

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

In the following example, the LSR will use the downstream-unsolicited advertisement mode for an LDP session on its interfaces.

```
#configure terminal
(config)#router ldp
(config-router)#advertisement-mode downstream-unsolicited
```

auto-targeted-session

Use this command at remote LFA node, to accept received targeted hello and allow creating TLDP session dynamically to establish rLFA tunnel. This command is used for remote LFA only.

Use the no parameter to disable dynamically TLDP session creation.

Dynamically created TLDP session can be deleted only when "auto-targeted-session" or "fast-reroute" configuration is removed.

Command Syntax

```
auto-targeted-session
no auto-targeted-session
```

Parameters

None

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#router ldp
(config-router)#auto-targeted-session
(config-router)#
```

clear ldp adjacency

Use this command to clear an adjacency with a specified peer, or to clear all adjacencies for the current LSR.

Command Syntax

```
clear ldp adjacency (A.B.C.D|*)
```

Parameters

`*`	Specify to clear all adjacencies.
`A.B.C.D`	Specify to clear IPv4 address of the peer.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp adjacency 123.123.123.33
```

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clear ldp session

Use this command to clear a session established with a specified peer, or to clear all sessions for the current LSR.

Command Syntax

```
clear ldp session (A.B.C.D|*)
```

Parameters

`*`	Specify to clear all sessions.
`A.B.C.D`	Specify to clear IPv4 address of the peer.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp session 123.123.123.33
```

clear ldp statistics

Use this command to clear LDP statistics. This command clears the count per each operation filtered by an advertisement list.

Command Syntax

```
clear ldp statistics
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp statistics
```

clear ldp statistics advertise-labels

Use this command to clear LDP advertise-labels statistics. This command clears the count per each operation filtered by an advertisement list.

Command Syntax

```
clear ldp statistics advertise-labels
clear ldp statistics advertise-labels for PREFIX
clear ldp statistics advertise-labels for PREFIX to PEER
```

Parameters

`advertise-labels`	Specify the IP prefix list of advertise-labels.
`for`	Specify the permitted destinations.
`PREFIX`	Specify the destinations that have their labels advertised.
`to`	Specify the given neighbor.
`PEER`	Specify the LDP neighbors that receive these advertisements.

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#clear ldp statistics advertise-labels
```

control-mode

Use this command to set the control mode for label processing. Ordered processing sets the mode to strict chain-of-command; an LSR replies to a request packet from an LSR higher in the chain only after it receives a label from an LSR lower in the chain. Independent processing sets the mode to instant replies.

In independent control mode, each LSR might advertise label mappings to its neighbors at any time. In independent downstream-on-demand mode, an LSR might answer requests for label mappings immediately, without waiting for a label mapping from the next hop. In independent downstream unsolicited mode, an LSR might advertise a label mapping for an Forwarding Equivalence Class (FEC) to its neighbors whenever it is prepared to label-switch that FEC. In independent mode, an upstream label can be advertised before a downstream label is received.

In ordered control mode, an LSR may initiate the transmission of label mapping only for an FEC for which it has a label mapping for the FEC next hop, or for which the LSR is the egress. For each FEC for which the LSR is not the egress and no mapping exists, the LSR must wait until a label from a downstream LSR is received. An LSR may be an egress for some FECs and a non-egress for others. Changes in control mode only affect labels that were sent or received after the change was made.

Use the `no` parameter to revert to default control mode.

Note: Control mode "independent" is supported with advertisement mode "DU" only.

Note: When the advertisement mode is set as "DU", control mode automatically sets to "independent".

Note: Control mode "independent" is not supported with advertisement mode "DOD".

Note: Control mode "ordered" is supported with advertisement mode "DOD" only.

Note: Control mode "ordered" is not supported with advertisement mode "DU".

Note: When the advertisement mode is set as "DOD", control mode automatically sets to "ordered".

Command Syntax

```
control-mode (ordered|independent)
no control-mode
```

Parameters

`independent`	Sets control mode to independent processing.
`ordered`	Sets control mode to ordered processing.

Command Mode

Router mode

Default

By default, control mode is independent

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#control-mode ordered
```

debug ldp advertise-labels

Use this command to enable the debugging of LDP advertise-label events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp advertise-labels
no debug ldp advertise-labels
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp advertise-labels
```

debug ldp all

Use this command to enable the debugging of all LDP events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp all
no debug ldp all
no debug all
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp all
```

debug ldp dsm

Use this command to enable the debugging of LDP DSM events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp dsm
no debug ldp dsm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp dsm
```

debug ldp events

Use this command to enable the debugging of all LDP events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp events
no debug ldp events
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp advertise-labels
(config)#debug ldp all
(config)#debug ldp dsm
(config)#debug ldp events
```

debug ldp fsm

Use this command to enable the debugging of LDP FSM events.

On using the debug command, the router continues to generate an output until the no parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the log syslog command in configure mode to redirect the debugging output to a file or the syslog.

Use the no parameter with this command to disable this function.

Command Syntax

```
debug ldp fsm
no debug ldp fsm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp fsm
```

debug ldp hexdump

Use this command to enable the debugging of LDP hexdump events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp hexdump
no debug ldp hexdump
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp hexdump
```

debug ldp inter-area

Use this command to enable the debugging of LDP inter-area events.

On using the debug command, the router continues to generate an output until the no parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the log syslog command in configure mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp inter-area
no debug ldp inter-area
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 4.0.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp inter-area
```

debug ldp nsm

Use this command to enable the debugging of LDP NSM events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp nsm
no debug ldp nsm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp nsm
```

debug ldp packet

Use this command to enable the debugging of LDP packet events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp packet
debug ldp packet (notification|hello|initialization|keepalive|address|label)
no debug ldp packet
no debug ldp packet (notification|hello|initialization|keepalive|address|label)
```

Parameters

`notification`	Debug LDP notification packets.
`hello`	Debug LDP hello packets.
`initialization`	Debug LDP initialization packets.
`keepalive`	Debug LDP keepalive packets.
`address`	Debug LDP address (withdraw) packets.
`label`	Debug LDP address label packets.

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp packet hello
```

debug ldp usm

Use this command to enable the debugging of LDP USM events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp usm
no debug ldp usm
```

Parameters

None

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp usm
```

debug ldp vc usm

Use this command to enable the debugging of LDP VC events.

On using the debug command, the router continues to generate an output until the `no` parameter is used with this command. The debug output and system error messages are written on the virtual terminal. Use the `log syslog` command in `configure` mode to redirect the debugging output to a file or the syslog.

Use the `no` parameter with this command to disable this function.

Command Syntax

```
debug ldp vc dsm
debug ldp vc usm
no debug ldp vc dsm
no debug ldp vc usm
```

Parameters

`dsm`	Debug LDP downstream SM.
`usm`	Debug LDP upstream SM.

Command Mode

Configure mode, Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#log syslog
(config)#debug ldp vc dsm
(config)#debug ldp vc usm
```

disable-ldp

Use this command to disable LDP IPv4 on a specified interface.

This command disables the transmission of Hello packets through the current interface, and clears all created sessions and adjacencies for this interface. Use `disable-ldp` alone to disable only LDP IPv4 on the interface.

Command Syntax

```
disable-ldp (ipv4|)
```

Parameters

`ipv4`	Disables IPv4 on the interface.

Default

By default, disable ldp is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following example disables LDP IPv4 on interface eth0.

```
#configure terminal
(config)#interface eth0
(config-if)#disable-ldp
```

The following example disables LDP IPv4 on interface eth0.

```
#configure terminal
(config)#interface eth0
(config-if)#disable-ldp ipv4
```

enable-ldp

Use this command to enable LDP IPv4 on a specified interface. This command enables the transmission of Hello packets through the current interface, so that LDP adjacencies and LDP sessions can be created.

Note: The corresponding interface must be enabled for label-switching using the label-switching command.

Command Syntax

```
enable-ldp ipv4
```

Parameters

None

Default

By default, enable ldp is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following example enables LDP IPv4 on interface eth0.

```
#configure terminal
(config)#interface eth0
(config-if)#enable-ldp ipv4
```

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explicit-null

Use this command to configure the router to send explicit-null labels for directly connected FECs instead of implicit-null labels. Implicit-nulls are the default labels.

This command controls the label value advertised on the egress router of an LSP. By default, implicit null label (label 3) is advertised for directly connected FECs. LDP advertises an Implicit Null label that causes the previous hop router to perform penultimate hop popping. Use the `explicit null` command to avoid the penultimate router from penultimate hop popping, and to force it to replace the incoming label with the explicit null label.

Note: Do not use this command if the LDP is concurrently used for MPLS/BGP VPNs.

Use the `no` parameter to stop sending explicit-null labels for directly connected FECs and resume sending implicit-null labels for them.

Command Syntax

```
explicit-null
no explicit-null
```

Parameters

None

Default

By default, sends implicit-null labels.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#explicit-null
```

fast-reroute

Use this command to enable the installation of backup paths advertised by IGP LFA (and/or rLFA) fast reroute.

Use no form CLI to disable the feature.

Command Syntax

```
fast-reroute
no fast-reroute
```

Parameters

None

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 5.1.

Examples

```
#configure terminal
(config)#router ldp
(config)fast-reroute
```

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global-merge-capability

Use this command to override the default merge capability setting of all the interfaces for the current LSR.

The merge capability aggregates multiple incoming flows with the same destination address into a single outgoing flow. This reduces the label-space shortage by sharing labels for different flows with the same destination, or the same FEC (Forwarding Equivalence Class).

Use the `no` parameter to revert to the default merge capability settings of all the interfaces for this LSR.

Command Syntax

```
global-merge-capability (merge-capable|non-merge-capable)
no global-merge-capability
```

Parameters

`merge-capable` Maps all incoming labels that are destined for the same FEC to the same outgoing label (this is the Ethernet default.)

`non-merge-capable`
Maps all incoming labels, regardless of destination FEC to unique outgoing labels (this is the non-Ethernet default.)

Default

By default, global merge capability is merge capable.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#global-merge-capability merge-capable
```

graceful-restart

Use this command to enable the Graceful-Restart capability for LDP.

Use the `no` parameter to disable the GR capability for LDP.

Command Syntax

```
graceful-restart full
graceful-restart helper-only
graceful-restart timers max-recovery <15-600>
graceful-restart timers neighbor-liveness <5-300>
no graceful-restart
no graceful-restart timers max-recovery
no graceful-restart timers neighbor-liveness
```

Parameters

`full`	Configuring with full enable the complete GR capability
`helper-only`	Configuring with helper-only enables only helper mode
`timers`	Non-default recovery and reconnect timer values.
`max-recovery`	Maximum recovery time
`<15-600>`	Interval until which LDP preserves route after peer restart
`neighbor-liveness`	Neighbor Liveness Time
`<5-300>`	Hold timer for a targeted LDP peer

Default

GR capability is not enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#graceful-restart full
(config-router)#graceful-restart helper-only
(config-router)#graceful-restart timers max-recovery 100
(config-router)#graceful-restart timers neighbor-liveness 200
```

hello-interval

Use this command to set the interval after which `hello` packets are sent out.

LDP defines a mechanism for discovering adjacent Label Switching Routers (LSRs) that participate in label switching (adjacencies). Hello messages are sent to the All Routers Multicast Group (224.0.0.2). Whenever a new router comes up, it sends out a hello packet to a specified, multicast address announcing itself to the network. Every router directly connected to the network receives the packet. Receipt of a hello packet from another LSR creates a `hello adjacency` with that LSR. Use this command to specify the interval after which the hello packets will be sent.

Used as a global command, the hello-interval value may be overridden by the hello-interval set on the interface (see ldp hello-interval). For optimum performance, set this value to no more than one-third the value of the hold-time specified.

Use the `no` parameter to revert to default hello interval.

Command Syntax

```
hello-interval <1-21845>
no hello-interval
```

Parameters

`<1-21845>`	Specify the interval in seconds. The default is 5 seconds.

Default

By default, hello interval is 5 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

This example shows how to set the hello-interval value for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#hello-interval 35

(config-router)#no hello-interval
```

hold-time

Use this command to set the global value for the hold-time after which the LSR rejects adjacencies.

An LSR maintains a record of `hellos` received from peers. `Hold-time` specifies the time an LSR maintains its record of hellos from a peer on not receiving another hello from that peer. A pair of LSRs negotiates the hold-time they use for hellos from each other. Each proposes a hold time value, and the LSR uses the lower of the two hold-time values. The hold-time value set on the interface overrides the hold-time value set by this command (see ldp hold-time). For optimum performance, set this value to no less than three times the value of the hello-interval specified.

Use the `no` parameter to revert to the default hold time.

Command Syntax

```
hold-time <3-65535>
no hold-time
```

Parameters

`<3-65535>`	Specify the hold-time value in seconds.

Default

By default, hold time is 15 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the hold-time value for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#hold-time 635

(config-router)#no hold-time
```

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import-bgp-routes

Use this command to import BGP routes into LDP. BGP routes are not imported into LDP by default.

Use the `no` parameter to flush out all BGP routes currently being used by LDP, and to reject any further BGP specific routing updates from OcNOS.

Command Syntax

```
import-bgp-routes
no import-bgp-routes
```

Parameters

None

Default

By default, import bgp route is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#import-bgp-routes
```

inter-area-lsp

Use this command to enable creation of inter-area LSPs.

Use the `no` form of the command to disable this configuration.

Command Syntax

```
inter-area-lsp (PREFIX_ACL|)(config-only|)
no inter-area-lsp
```

Parameters

`PREFIX_ACL`	Access-list name for Prefix Based inter-area lsp
`config-only`	Optional. When this option is used, existing LDP sessions are not torn down.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 4.0.

Example

```
#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp

#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp config-only

#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp acl1

#configure terminal
(config)#router ldp
(config-router)#inter-area-lsp acl1 config-only
```

keepalive-interval

Use this command to set the global value for the interval after which keep-alive packets are sent out.

Each LSR must send keep-alive messages at regular intervals to its LDP peers to keep the sessions active. The keep-alive interval determines the time interval between successive keep-alive messages. Use this command to set this interval. This value is overridden by the keep-alive interval set on the interface. For optimum performance, set this value to no more than one-third the value of the specified keep-alive time-out value.

Use the `no` parameter to revert to default keep-alive interval.

Command Syntax

```
keepalive-interval <10-21845>
no keepalive-interval
```

Parameters

`<10-21845>`	Specify the value of interval in seconds.

Default

By default, keepalive interval is 10 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the keep-alive timer for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#keepalive-interval 635

(config-router)#no keepalive-interval
```

keepalive-timeout

Use this command to set the global value for the time-out after which sessions are rejected.

Use this command to set the time period for which an LSR must wait for successive keep-alive messages from LDP peers. The keep-alive time-out value is overridden by the keep-alive time-out set on the interface (see ldp keepalive-timeout). For optimum performance, set this value to no less than three times the value of the specified keep-alive interval value.

Use the `no` parameter to revert to default keep-alive time-out.

Command Syntax

```
keepalive-timeout <30-65535>
no keepalive-timeout
```

Parameters

`<30-65535>`	Specify the time-out value in seconds.

Default

By default, keepalive timeout is 30 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the keep-alive time-out value for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#keepalive-timeout 635

(config-router)#no keepalive-timeout
```

label-retention-mode

Use this command to set the retention mode to be used for all labels exchanged.

When an LSR receives a label binding for a particular FEC (Forwarding Equivalence Class) from another LSR that is not its next hop for that FEC, it might keep track of such bindings or discard them. Use the `liberal` parameter to retain all labels binding to FEC received from label distribution peers, even if the LSR is not the current next-hop. Use the `conservative` parameter to maintain only the label bindings for valid next-hops in a LSP. Liberal label retention mode allows for quicker adaptation to routing changes, whereas conservative label retention mode requires an LSR to maintain fewer labels.

Note: The retention mode value set on the interface (see ldp label-retention-mode) overrides the value set by this command.

Note: Any changes made to the retention mode for an interface (after a session is already operational) will only apply to labels received after the mode has been changed. All previously received labels will remain as they were.

Use the `no` parameter to revert to default retention mode.

Note: label-retention-mode "liberal" is supported with advertisement mode "DU" only.

Note: label-retention-mode "liberal" is not supported with advertisement mode "DOD".

Note: When the advertisement mode is set as "DU", label-retention-mode automatically sets to "liberal".

Note: label-retention-mode "conservative" is supported with advertisement mode "DOD" only.

Note: label-retention-mode "conservative" is not supported with advertisement mode "DU".

Note: When the advertisement mode is set as "DOD", label-retention-mode automatically sets to "conservative".

Command Syntax

```
label-retention-mode (conservative|liberal)
no label-retention-mode (conservative|liberal)
```

Parameters

`conservative`	Specify to delete all unused labels and FECs.
`liberal`	Specify to retain all labels, regardless of use.

Default

By default, label retention mode is liberal

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the retention mode for all interfaces of an LSR.

```
#configure terminal
(config)#router ldp
(config-router)#label-retention-mode liberal
```

ldp advertisement-mode

Use this command to set the label advertisement mode for an interface for the current LSR to either downstream-on-demand (label is sent only when requested) or downstream-unsolicited (label is sent unrequested). Specifying downstream-on-demand and downstream-unsolicited mode affects which LSR initiates mapping requests and mapping advertisements.

This is an interface-specific command; it overrides the advertisement mode set for an LSR using the advertisement-mode command (see advertisement-mode). Use this command after the advertisement-mode command sets all the interface advertisement modes. In addition, users should use this command before starting the interface, since all affected sessions will be closed and restarted.

Use the `no` parameter to revert to the advertisement mode value set for the main LDP process.

Command Syntax

```
ldp advertisement-mode (downstream-on-demand|downstream-unsolicited)
no ldp advertisement-mode (downstream-on-demand|downstream-unsolicited)
```

Parameters

`downstream-on-demand`

Indicates that the sent label was requested. When a user uses this parameter, a router distributes a label to a peer only if there is a pending label request from a peer. The reaction of the downstream router to this request depends on the label advertising mode supported on the next hop. The downstream-on-demand mode is typically used with the conservative label retention mode.

`downstream-unsolicited`

Indicates that the label was sent unrequested. This parameter distributes labels to peers without waiting for a label request. This mode is typically used with the liberal label retention mode.

Default

By default, ldp advertisement mode is downstream unsolicited mode

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#ldp advertisement-mode downstream-on-demand
```

ldp hello-interval

Use this command to set the interval for sending multicast Hello packets via an interface.

LDP defines a mechanism for discovering adjacent Label Switching Routers (LSR) that participate in label switching (adjacencies). Whenever a new router comes up, it sends out a hello packet to a specified, multicast address announcing itself to the network. Every router directly connected to the network receives the packet. Receipt of a hello packet from another LSR creates a hello adjacency with that LSR. Use this command to specify the interval after which the hello packets will be sent.

For optimum performance, set the hello-interval value to no more than one-third the hold-time value.

Note: This command is an interface-specific command and overrides the value set for an LSR using the global hello-interval command.

Use the `no` parameter with this command to revert to the hello-interval value set for the main LDP process.

Command Syntax

```
ldp hello-interval <1-21845>
no ldp hello-interval
```

Parameters

`<1-21845>`	Specify the interval in seconds.

Default

By default, ldp hello interval is 5 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

This example shows how to set the hello-interval for a specific interface.

```
#configure terminal
(config)#interface eth0
(config-if)#ldp hello-interval 635

(config-if)#no ldp hello-interval
```

ldp hold-time

Use this command to set the hold-time value after which the LSR rejects adjacencies.

The hold-time timer is reset every time a hello packet is received from the peer in question. For optimum performance, set this value to no less than three times the hello-interval value.

Note: This command is an interface-specific command, and overrides the value set for an LSR using the global hold-time command.

Use the `no` parameter to revert to the hold-time value set for the main LDP process.

Command Syntax

```
ldp hold-time <3-65535>
no ldp hold-time
```

Parameters

`<3-65535>`	Specify the hold-time value in seconds.

Default

By default, ldp hold time is 15 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the hold-time for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp hold-time 635

(config-if)#no ldp hold-time
```

ldp keepalive-interval

Use this command to set the interval for sending keep-alive messages to the peer in order to maintain a session.

Each LSR must send keep-alive messages at regular intervals to its LDP peers to keep the sessions active. The keep-alive interval determines the time-interval between successive keep-alive messages. This command sets this interval.

Note: This command is an interface-specific command, and overrides the value set for an LSR using the global `keepalive-interval` command.

Use the `no` parameter to revert to the keep-alive interval set for the main LDP process.

Command Syntax

```
ldp keepalive-interval <1-21845>
no ldp keepalive-interval
```

Parameters

`<1-21845>`	Specify the interval in seconds.

Default

By default, ldp keepalive interval is 10 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

This example shows how to set the hello-interval for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp keepalive-interval 635

(config-if)#no ldp keepalive-interval
```

ldp keepalive-timeout

Use this command to set the keep-alive time-out value for rejecting a session with a peer.

Use this command to set the time period for which an LSR must wait for successive keep-alive messages from LDP peers. The keep-alive timer is reset every time a keep-alive packet is received from the peer in question. For optimum performance, set this value to no more than three times the keep-alive interval value.

Note: This command is an interface-specific command and overrides the value set for an LSR using the global `keepalive-timeout` command.

Use the `no` parameter to revert to the keep-alive time-out set for the main LDP process.

Command Syntax

```
ldp keepalive-timeout <3-65535>
no ldp keepalive-timeout
```

Parameters

<3-65535>	Specify the value in seconds.

Default

By default, ldp keepalive timeout is 30 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the keep-alive time-out timer for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp keepalive-timeout 635

(config-if)#no ldp keepalive-timeout
```

ldp label-retention-mode

Use this command to set the retention mode to be used for all labels exchanged via the given interface.

When an LSR receives a label binding for a particular FEC (Forwarding Equivalence Class) from another LSR that is not its next hop for that FEC, it might keep track of such bindings or discard them. Use the `liberal` parameter to retain all labels binding to FEC received from label distribution peers, even if the LSR is not the current next-hop. Use the `conservative` parameter to maintain only the label bindings for valid next-hops in a LSP. Liberal label retention mode allows for quicker adaptation to routing changes, whereas conservative label retention mode requires an LSR to maintain fewer labels.

Note: The retention mode value set on the interface (see label-retention-mode) overrides the value set by this command. This command is an interface-specific command, and overrides the setting for an LSR using the global `label-retention-mode` command.

Use the `no` parameter to revert to the retention mode set for the main LDP process.

Command Syntax

```
ldp label-retention-mode (conservative|liberal)
no ldp label-retention-mode (conservative|liberal)
```

Parameters

`conservative`	Specify to delete all unused labels and FECs.
`liberal`	Specify to retain all labels, regardless of use.

Default

By default, ldp label retention mode is liberal

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows how to set the label retention mode for a specific interface:

```
#configure terminal
(config)#interface eth0
(config-if)#ldp label-retention-mode liberal
```

ldp multicast-hellos

Use this command to enable multicast hello exchange on a specified interface.

Use the `no` parameter to disable multicast hello exchange. R

Command Syntax

```
ldp multicast-hellos
no ldp multicast-hellos
```

Parameters

None

Default

By default, ldp multicast hello is enabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#ldp multicast-hellos
```

ldp-optimization

This command helps optimize the resetting of an LDP session by enabling the following two scalability features for LDP:

- Resets the session keepalive timer on receipt of a hello message
- Resets the hold timer on receipt of any LDP control message

Use the `no` parameter to disable the two previously listed scalability features.

Command Syntax

```
ldp-optimization
no ldp-optimization
```

Parameters

None

Default

By default, ldp optimization is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#ldp-optimization
```

loop-detection

Use this command to enable loop detection on the current LSR. This command detects looping LSPs, and prevent Label Request messages from looping because of non-merge capable LSRs. This loop detection mechanism is useful for networks of non time-to-live (non TTL) decrementing devices that can not allocate resources among traffic flows.

There are two methods supported for the loop detection mechanism: A Hop Count detection system, that is always enabled; and the Path Vector detection system, that can be toggled:

- Hop Count - During the setup of an LSP, the LSP passes a hop count with the LSP setup messages. This hop count is incremented by each node router participating in LSP establishment. If the hop count exceeds the maximum configured value, the LSP setup process is stopped, and a notification message is passed back to the message originator.
- Path Vector - A path vector contains a list of LSR identifiers. This is passed as a part of LSP setup messages. Each LSR participating in the LSP establishment adds its own LSR identifier to the path vector. If an LSR finds its own identifier in the path vector, it drops the message, and sends a message back to the originator.

The use of these messages ensures that a loop is detected while establishing a label switched path and before any data is passed over that LSP.

Use the `no` parameter to disable loop detection.

Command Syntax

```
loop-detection
no loop-detection
```

Parameters

None

Default

By default, loop detection is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#loop-detection
```

loop-detection-hop-count

Use this command to set the loop detection hop count, which determines the maximum hop-count value.

This command sets the maximum hop count value, which specifies the permitted maximum permitted hop-count. An LSR that detects a maximum hop count behaves as if the containing message has traversed a loop. The use of this command ensures that a loop is detected while establishing a label switched path before any data is passed via LSP.

Use the `no` parameter to revert to the default loop detection count

Command Syntax

```
loop-detection-hop-count <1-255>
```

Parameters

`<1-255>`	Indicates the loop detection hop count.

Default

By default, loop detection hop is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#loop-detection-hop-count 128
```

loop-detection-path-vec-count

Use this command to set the loop detection vec (vector) count, which determines the maximum supported path vectors.

This command sets the maximum supported path vectors for loop detection, which specifies the permitted path vector length. An LSR that detects a path vector has reached the maximum length behaves as if the containing message has traversed a loop. This command ensures that a loop is detected while establishing a label switched path before any data is passed over that LSP.

Use the `no` parameter to revert to the default loop detection count

Command Syntax

```
loop-detection-path-vec-count <1-255>
```

Parameters

`<1-255>`	Indicates the loop detection hop count.

Default

By default, loop detection path vec count is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#loop-detection-path-vec-count 123
```

mpls ldp-igp sync isis

Use this command to enable LDP ISIS synchronization and to set the holddown timer for synchronization.

Use the `no` parameter to disable the LDP ISIS synchronization.

Note: Holddown timer value should be higher than LDP IGP sync timer.

Command Syntax

```
mpls ldp-igp sync isis (level-1|level-2|level-1-2) (holddown-timer <1-2147483>| )
```

Parameters

`level-1|level-2|level-1-2`
: The ISIS level.

`holddown-timer`
: How long IGP should wait for LDP to converge in seconds.

Default

None

Command Mode

Interface configuration mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
#int eth 1
#mpls ldp-igp sync isis level-1-2 holddown-timer 500
```

mpls ldp-igp sync ospf

Use this command to enable LDP-OSPF synchronization. This command also provides option to configure the hold-down timer for which OSPF will wait for LDP to converge and advertises Max cost. When the configured time expires, OSPF starts advertising the actual cost in the Router-LSA.

Note: Holddown timer value should be higher than LDP IGP sync timer.

Command Syntax

```
mpls ldp-igp sync ospf (holddown-timer <1-2147483>|)
```

Parameters

`holddown-timer`	Set holddown timer for the OSPF Sync
`<1-2147483>`	Hold down timer in seconds

Default

OSPF waits infinite when no hold-down timer is configured.

Command Mode

Interface configuration mode

Applicability

This command was introduced before OcNOS version 4.0.

Example

Enabling OSPF-LDP sync in interface eth3

```
#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
(config)#int eth3
(config-if)#mpls ldp-igp sync ospf
(config-if)#end
```

Enabling OSPF-LDP sync with holdown-timer enabled

```
#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
(config)#int eth3
(config-if)#mpls ldp-igp sync ospf holddown-timer 200
(config-if)#no mpls ldp-igp sync ospf
(config-if)#end
#
```

mpls ldp-igp sync-delay

Use this command to set the time delay for LDP-IGP synchronization.

Use the `no` parameter to disable the time delay.

Command Syntax

```
mpls ldp-igp sync-delay <5-60>
no mpls ldp-igp sync-delay
```

Parameters

`sync-delay`	Time delay for LDP to converge in seconds.
`<5-60>`	Time delay for notification of LDP convergence to IGP, in seconds

Default

If not configured the delay will be 0 seconds.

Command Mode

Interface configuration mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config-if)# interface eth0
(config-if)# mpls ldp-igp sync-delay 15
(config-if)# no mpls ldp-igp sync-delay
```

multicast-hellos

Use this command to enable multicast hello exchange on all interfaces enabled for LDP. This is used for auto-discovery of LDP peers on directly connected networks. This option is enabled by default.

Use the `no` parameter with this command to disable multicast hello exchange.

Command Syntax

```
multicast-hellos
no multicast-hellos
```

Parameters

None

Default

By default, multicast hello is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#multicast-hellos
```

neighbor

Use this command to configure neighbors of LDP.

Use the `no` parameter with this command to unconfigure the LDP neighbor.

Command Syntax

```
neighbor A.B.C.D auth AUTH-TYPE password (0|7) WORD
no neighbor A.B.C.D auth AUTH-TYPE password
```

Parameters

`A.B.C.D`	Neighbor address
`auth AUTH-TYPE`	Authentication Type md5
`password`	Set password to the neighbor
`(0|7)`	Password Type
`WORD`	Password

Default

By default, neighbor is disabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#neighbor 1.1.1.1 auth md5 password 0 myPass

(config-router)#no neighbor 1.1.1.1 auth md5 password
```

propagate-release

Use this command to propagate the release of labels to downstream routers.

Use the `no` parameter to prevent the propagate-release of labels.

Command Syntax

```
propagate-release
no propagate-release
```

Parameters

None

Default

By default, propagate release is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#propagate-release
```

pw-status-tlv

Use this command to enable the use of the PW Status TLV to signal the pseudowire status.

Use the `no` option with this command to disable the use of the PW Status TLV to signal the pseudowire status.

Command Syntax

```
pw-status-tlv
no pw-status-tlv
```

Parameters

None

Default

By default, pw status tlv is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#pw-status-tlv
```

request-labels-for

Use this command to request labels for the prefixes in the given IP prefix list. LDP request labels for the prefixes only if the valid and exact route is present for that prefix.

Use the no form of this command to disable multicast hello exchange.

Command Syntax

```
request-labels-for prefix-list-ipv4 NAME
no request-labels-for prefix-list-ipv4
```

Parameters

NAME	IPv4 prefix list name

Command Mode

LDP router mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#request-labels-for prefix-list-ipv4 myPrefixList
```

request-retry

Use this command to enable the retry of requests once a request for a label has been rejected for a valid reason. This command enables the LSR to send a maximum of five label requests if a label request is rejected by an LDP peer.

Use the `no` parameter to disable the retry of requests.

Command Syntax

```
request-retry
no request-retry
```

Parameters

None

Default

By default, request retry is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#request-retry
```

request-retry-timeout

Use this command to set the interval between retries. Before this time is over, a request is re-sent to a peer. This command changes the interval between request messages that are resent to a peer to account for routing changes.

Use the `no` parameter to revert to the default request-retry time-out set.

Command Syntax

```
request-retry-timeout <1-65535>
no request-retry-timeout
```

Parameter

`<1-65535>`	Specify the interval between retries in seconds.

Default

By default, timeout is 5 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#request-retry-timeout 512

(config-router)#no request-retry-timeout
```

restart ldp graceful

Use this command to restart ldp gracefully.

Command Syntax

```
restart ldp graceful
```

Parameter

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#restart ldp graceful

% Warning : LDP process will stop and needs to restart manually,
You may loose LDP configuration, if not saved
Proceed for graceful restart? (y/n):y
```

rlfa-ilm-optimization

Use this command to enable ILM optimization for rLFA. When ILM optimization is enabled, ILM delete and POP operations are delayed. ILM delete/POP configuration is delayed to make sure rLFA backup path is not removed immediately upon IGP network convergence.

Use the `no` parameter with this command to revert this configuration.

Command Syntax

```
rlfa-ilm-optimization
no rlfa-ilm-optimization
```

Parameter

None

Default

By default, ILM optimization is disabled.

Command Mode

Router(LDP) Config mode.

Applicability

This command was introduced before OcNOS version 6.2.0.

Example

```
(config)#router ldp
(config-router)# rlfa-ilm-optimization
```

router ldp

This command is used to enter the LDP specific command-line mode in which global attributes for the LDP process can be set. Without this command, the LSR does not perform any LDP operations, such as sending `hello` packets.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
router ldp
no router ldp
```

Parameters

None

Default

By default, router ldp is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following example shows the change in the prompt after using this `router ldp` command to enter router mode.

```
#configure router
(config)#router ldp
(config-router)#
```

router-id

Use this command to set the router-id to the supplied IP address; the router uses this address to generate the LDP-ID.

OcNOS has three methods to choose the router-id of LDP. The first priority router-id is the configured router-id in router mode (local configured router-id). The second priority router-id is the configured router-id in configure mode (global configured router-id). The lowest priority router-id is chosen by OcNOS among interfaces (global computed router-id).

Use the `no` parameter with this command to revert to using the first IP address configured on the box as the router-id for LDP-ID generation purposes.

Command Syntax

```
router-id A.B.C.D
no router-id A.B.C.D
no router-id
```

Parameter

`A.B.C.D`	Indicates the LDP router ID value.

Default

By default, router id is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure router
(config)#router ldp
(config-router)#router-id 123.123.123.8
```

snmp restart ldp

Use this command to restart SNMP in Label Distribution Protocol (LDP)

Command Syntax

```
snmp restart ldp
```

Parameters

None

Default

By default, snmp restart ldp is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#snmp restart ldp
```

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targeted-peer ipv4

Use this command to enter a targeted IPv4 LDP peer mode.

A targeted session is an LDP session between non-directly connected LSRs. Set this command to send a targeted hello messages to specific IP addresses. This command is specific to a targeted IPv4 LDP peer.

Command Syntax

```
targeted-peer ipv4 A.B.C.D
no targeted-peer ipv4 A.B.C.D
```

Parameter

A.B.C.D	Specify the IPv4 address of the targeted peer.

Default

By default, targeted peer IPv4 is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router ldp
(config-router)#targeted-peer ipv4 10.10.10.10
(config-router-targeted-peer)#
```

targeted-peer-hello-interval

Use this command to set the interval for sending unicast `hello` packets to targeted peers.

Use the `no` parameter with this command to revert to the default targeted-peer hello-interval value.

Command Syntax

```
targeted-peer-hello-interval <1-21845>
no targeted-peer-hello-interval
```

Parameter

`<1-21845>`	Specify the interval in seconds.

Default

By default, targeted peer hello interval is 15 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#targeted-peer-hello-interval 1
```

targeted-peer-hold-time

Use this command to set the time-out value that is the time that the router waits before rejecting an adjacency with targeted peers.

Use the `no` parameter to revert to the default targeted-peer hold-time value.

Command Syntax

```
targeted-peer-hold-time <3-65535>
no targeted-peer-hold-time
```

Parameter

`<3-65535>`	Specify the interval in seconds.

Default

By default, hold time is 45 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router ldp
(config-router)#targeted-peer-hold-time 555

(config-router)#no targeted-peer-hold-time
```

transport-address ipv4

Use this command to configure the IPv4 transport address for a label space.

The transport address is the address used for the TCP session over which LDP is running. Use this command to manually configure the transport address. Transport addresses may either be bound to a loopback interface, or to a physical interface that is bound to the label space in question. A transport address can also be manually configured using the CLI with the loopback address as the transport address.

Note: The CLI accepts only the loopback address to be configured as the transport address.

Use the `no` parameter to stop using the transport address as the IPv4 transport address. If the label space is not specified for either form of this command, a label space of zero is assumed.

Command Syntax

```
transport-address ipv4 A.B.C.D
transport-address ipv4 A.B.C.D 0
no transport-address ipv4 A.B.C.D
no transport-address ipv4 A.B.C.D 0
```

Parameters

`A.B.C.D`	Specify the IPv4 address to be used as the transport address. Only addresses bound to a loopback interface are valid for manual transport address configuration.
`0`	Platform-wide label space for which a transport address is being configured (Platformwide labels are used for all interfaces that can share the same labels)

Default

Transport addresses are chosen for label spaces. By default, the loopback address is selected as the transport address. If a loopback address is not configured, the label space value is examined. The IP address of the interface is bound to the same label space is chosen as the transport address.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure router
(config)#router ldp
(config-router)#transport-address ipv4 10.10.0.5 0
```

CHAPTER 2 LDP Show Commands

This chapter provides an alphabetized reference for each of the LDP commands. It includes the following commands:

show debugging ldp

Use this command to display the status of the debugging of the LDP system.

Command Syntax

```
show debugging ldp
```

Parameter

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show debugging ldp` command.

```
#show debugging ldp
LDP debugging status:
  LDP event debugging is on
  LDP packet debugging is on
  LDP finite state machine debugging is on
  LDP pdu hexdump debugging is on
  LDP downstream state machine debugging is on
  LDP upstream state machine debugging is on
  LDP trunk state machine debugging is on
  LDP QoS debugging is on
  LDP CSPF debugging is on
  LDP VC USM debugging is on
  LDP VC DSM debugging is on
  LDP NSM debugging is on
  LDP Advertise-labels debugging is on
#
```

Table 2-1 explains the show command output fields.

Table 2-1: show debugging ldp output fields details

Field	Description
LDP debugging status	Status of the LDP debugging protocol.

show ldp

Use this command to display basic LDP attributes defined for the current LSR.

Command Syntax

```
show ldp
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following is a sample output from the `show ldp` command displaying basic LDP attributes.

```
#show ldp
Router ID : 20.1.1.1
LDP Version : 1
Global Merge Capability : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode : Liberal
Label Control Mode : Independent
Instance Loop Detection : On
Instance Hop Count Limit : 255
Instance Path Vec Count : 255
Request Retry : Off
Propagate Release : Disabled
Graceful Restart : Disabled
Hello Interval : 5
Targeted Hello Interval : 15
Hold time : 15
Targeted Hold time : 45
Keepalive Interval : 10
Keepalive Timeout : 30
Request retry Timeout : 5
Transport Address data :
Labelspace 0 : 20.1.1.1 (in use)
Import BGP routes : No
#
```

Table 2-2 explains the show command output fields.

Table 2-2: show ldp output fields details:

Field	Description
Router ID	Router identifier in IP address format for this system.
LDP Version	Details of Link Layer Discovery Protocol (LLDP) version.
Global Merge Capability	Used to override the default merge capability setting of all the interfaces for the current LSR.
Label Advertisement Mode	Used to set the label advertisement mode for an interface for the current LSR to either downstream-on-demand (label is sent only when requested) or downstream-unsolicited (label is sent unrequested).
Label Retention Mode	Used for all labels exchanged via the given interface.
Label Control Mode	LSR generates a local label for a FEC which the router learned from routing table independently from other LSRs.
Loop Detection	Used to enable loop detection on the current LSR.
Loop Detection Count	Indicates the loop detection hop count.
Request Retry	Enables the LSR to send a maximum of five label requests.
Propagate Release	Used to propagate the release of labels to downstream routers.
Hello Interval	Sets the interval for sending unicast hello packets to peers.
Targeted Hello Interval	Sets the interval for sending unicast hello packets to targeted peers.
Hold time	Sets the time-out value to peers.
Targeted Hold time	Sets the time-out value that is the time that the router waits before rejecting an adjacency with targeted peers.
Keepalive Interval	Used to set the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Request retry Timeout	Used to set the interval between retries.
Targeted Hello Receipt	Status of the hello receipt.
Transport Address	The transport address is the address used for the TCP session over which LDP is running.
Transport Interface	Interface is used for the TCP session over which LDP is running.
Import BGP routes	Used to import BGP routes into LDP.

show ldp adjacency

Use this command to display all the adjacencies for the current LSR.

Command Syntax

```
show ldp adjacency
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp adjacency` command displaying all the adjacencies for this LSR.

```
#show ldp adjacency
Remote-Address   Local-Address   Mode        Intf-Name  Holdtime   LDP-Identifier
11.11.11.11      12.0.1.20       Targeted    ge11       45         11.11.11.11:0
33.33.33.33      11.0.1.20       Targeted    ge9        45         33.33.33.33:0
44.44.44.44      20.0.1.20       Targeted    xe14       45         44.44.44.44:0
11.0.1.10        11.0.1.20       Interface   ge9        15         33.33.33.33:0
12.0.1.10        12.0.1.20       Interface   ge11       15         11.11.11.11:0
20.0.1.10        20.0.1.20       Interface   xe14       15         44.44.44.44:0
```

Table 2-3 explains the show command output fields.

Table 2-3: show ldp adjacency output fields details

Field	Description
Remote Address	IP address of the interface.
Local Address	Local address of the LDP adjacency.
Interface Name	Name of the interface.
Hold time	Sets the time-out value to peers.
LDP ID	LDP identifier for this protocol.

show ldp advertise-labels

Use this command to display the IP access list of LDP advertise-labels.

Command Syntax

```
show ldp advertise-labels
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp advertise-labels` command.

```
#show ldp advertise-labels
Advertisement spec:
    Prefix list = pfx1; Peer plist = pfx1
    Prevent the distribution of any assigned labels
```

Table 2-4 explains the show command output fields.

Table 2-4: show ldp advertise-labels output fields details

Field	Description
Advertisement spec	Details of the advertisement spec.
Prefix list	The label is advertised to all peers permitted by the peer plist.
Peer plist	The prefix list permits the prefix and there is a peer plist.

show ldp downstream

Use this command to display the status of all downstream sessions and the label information exchanged.

Command Syntax

```
show ldp downstream
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and was updated in OcNOS version 5.1.

Example

The following is an output from the `show ldp downstream` command showing the status of all downstream sessions.

When LDP LFA FRR in not enabled:

```
#show ldp downstream
Session peer 44.1.1.1:
  FEC               Nexthop Addr   State          Label       Req.ID      Attr
 192.168.254.0/24  connected      Established    impl-null   0
 33.1.1.1/32       10.0.4.1       Established    24323       0
 10.0.4.0/31       connected      Established    impl-null   0
 10.0.2.0/31       connected      Established    24322       0
 44.1.1.1/32       10.0.4.1       Established    impl-null   0
 10.0.3.0/31       10.0.4.1       Established    impl-null   0
Session peer 22.1.1.1:
  FEC               Nexthop Addr   State           Label      Req.ID      Attr
 192.168.254.0/24  connected      Established     impl-null  0
 10.0.3.0/31       connected      Established     24323      0
 10.0.1.0/31       connected      Established     impl-null  0
 33.1.1.1/32      10.0.1.1        Established     24324      0
 22.1.1.1/32      10.0.1.1        Established     impl-null  0
  10.0.2.0/31     10.0.1.1        Established     impl-null  0
```

When LDP LFA FRR in enabled:

```
#show ldp downstream
Codes: P - Primary route, B - Backup route
Session peer 44.1.1.1:
  FEC          Nexthop Addr     State          Label        Req.ID      Attr       Code
 192.168.254.0/24   connected      Established     impl-null   0
```

```
  33.1.1.1/32        10.0.4.1        Established     24323      0
P
  33.1.1.1/32        10.0.4.1        Established     24323      0
B
  10.0.4.0/31        connected       Established     impl-null   0
  10.0.2.0/31        connected       Established     24322      0
  10.0.2.0/31        10.0.4.1        Established     24322      0
B
  44.1.1.1/32        10.0.4.1        Established     impl-null   0
P
  10.0.3.0/31        10.0.4.1        Established     impl-null   0
P
Codes: P - Primary route, B - Backup route
Session peer 22.1.1.1:
  FEC                 Nexthop Addr     State           Label      Req.ID      Attr       Code
  192.168.254.0/24  connected         Established     impl-null  0
  10.0.3.0/31        connected        Established     24323      0
  10.0.3.0/31        10.0.1.1         Established    24323       0                       B
  10.0.1.0/31        connected        Established    impl-null   0
  33.1.1.1/32        10.0.1.1         Established    24324       0                       P
  33.1.1.1/32        10.0.1.1         Established    24324       0                       B
  22.1.1.1/32        10.0.1.1         Established    impl-null   0                       P
  10.0.2.0/31        10.0.1.1         Established    impl-null   0                       P
```

Table 2-5 explains the show command output fields.

Table 2-5: show ldp downstream output fields details

Field	Description
Session peer	Used to group and apply the configuration of general session commands to groups of neighbors that share common session configuration elements.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Nexthop addr	Displays the IP address of the next hop.
State	Displays the current status of the ldp.
Label	Details of the ldp downstream labels.
Req.ID	Request identifier for the protocol.
Attr	The attribute is used to sent to a customer router.
Code	Show if an entry is principal or backup.

show ldp fec

Use the following command to display all FECs (Forwarding Equivalence Classes) known to this LSR.

Command Syntax

```
show ldp fec
show ldp fec (prefix)
show mpls ldp fec
show mpls ldp fec (prefix|)
```

Parameter

prefix	Display prefix FEC information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and was updated in OcNOS version 5.1.

Example

When LDP LFA FRR in not enabled:

```
#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                  Code    Session             Out Label   ELC   Nexthop Addr
10.0.1.0/31          NL      22.1.1.1            impl-null   No    connected
                     E >     non-existent        none        No    connected
10.0.2.0/31          NL      44.1.1.1            24322       No    no nexthop
                     NL>     22.1.1.1            impl-null   No    10.0.1.1
10.0.3.0/31          NL      22.1.1.1            24323       No    no nexthop
                     NL>     44.1.1.1            impl-null   No    10.0.4.1
10.0.4.0/31          NL      44.1.1.1            impl-null   No    connected
                     E >     non-existent        none        No    connected
11.1.1.1/32          E >     non-existent        none        No    connected
22.1.1.1/32          NL>     22.1.1.1            impl-null   No    10.0.1.1
33.1.1.1/32          NL>     44.1.1.1            24323       No    10.0.4.1
                     NL>     22.1.1.1            24324       No    10.0.1.1
44.1.1.1/32          NL>     44.1.1.1            impl-null   No    10.0.4.1
192.168.254.0/24     NL      22.1.1.1            impl-null   No    connected
                     NL      44.1.1.1            impl-null   No    connected
                     E >     non-existent        none        No    connected
```

When LDP LFA FRR in enabled:

```
#show ldp fec
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
```

```
                    P - Primary route, B - LFA Backup route,
                    R - Remote LFA Backup route,
                    > - LSR will use this route for the FEC
FEC                   Code    Session          Out Label   ELC   Nexthop Addr
10.0.1.0/31           NL      22.1.1.1         impl-null   No    connected
                      E >     non-existent     none        No    connected
10.0.2.0/31           NLB>    44.1.1.1         24322       No    10.0.4.1
                      NLP>    22.1.1.1         impl-null   No    10.0.1.1
10.0.3.0/31           NLB>    22.1.1.1         24323       No    10.0.1.1
                      NLP>    44.1.1.1         impl-null   No    10.0.4.1
10.0.4.0/31           NL      44.1.1.1         impl-null   No    connected
                      E >     non-existent     none        No    connected
11.1.1.1/32           E >     non-existent     none        No    connected
22.1.1.1/32           NLP>    22.1.1.1         impl-null   No    10.0.1.1
33.1.1.1/32           NLP>    44.1.1.1         24323       No    10.0.4.1
                      NLB>    44.1.1.1         24323       No    10.0.4.1
                      NLP>    22.1.1.1         24324       No    10.0.1.1
                      NLB>    22.1.1.1         24324       No    10.0.1.1
44.1.1.1/32           NLP>    44.1.1.1         impl-null   No    10.0.4.1
1.1.1.1/32            NL      1.1.1.1          impl-null   No    no nexthop
                      NLP>    3.3.3.3          24320       No    30.1.1.1
                      NLB>    3.3.3.3          24320       No    30.1.1.1
                      NLP>    2.2.2.2          24320       No    20.1.1.1
                      NLB>    2.2.2.2          24320       No    20.1.1.1
2.2.2.2/32            NLR>    1.1.1.1          24324       No    1.1.1.1
                                                   (via 30.1.1.1,label 24320)
                      NLP>    2.2.2.2          impl-null   No    20.1.1.1
192.168.254.0/24      NL      22.1.1.1         impl-null   No    connected
                      NL      44.1.1.1         impl-null   No    connected
                      E >     non-existent     none        No    connected
```

Table 2-6 shows the codes at the end of each route entry that indicate where the route originated.

Table 2-6: Origin Codes

Origin Code	Description	Comments
E/N	Egress/Non-egress	LSR is egress/non-egress for this FEC.
L	LSR	LSR received a label for this FEC.
>		LSR will use this route for the FEC.
P	Primary route	When LDP LFA FRR is enabled
B	LFA Backup route	When LDP LFA FRR is enabled
R	Remote LFA Backup route	When LDP LFA FRR is enabled

Table 2-7 explains the show command output fields.

Table 2-7: show ldp fec output fields details

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Session	Reports the current session state.
Out Label	Label received from downstream neighbor for route.
ELC	Displays if route has ELC
Nexthop addr	Displays the IP address of the next hop.

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show ldp igp sync

Use the following command to display the LDP synchronization status.

Command Syntax

```
show ldp igp sync
show mpls ldp igp sync
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show ldp igp sync
eth1
LDP configured; LDP-IGP Synchronization enabled.
Sync status: sync achieved
Delay timer: Not Configured , Not Running
```

show ldp inter-area-fecs

Use this command to show all FECs using the LPM-based mapping procedure.

Command Syntax

```
show ldp inter-area-fecs
show ldp inter-area-fecs (ipv4|ipv6|) (count)
```

Parameter

`ipv4`	IPv4 FECs
`ipv6`	IPv6 FECs
`count`	Count of FECs

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 4.0 and the command was updated in OcNOS version 4.1.

Example

```
#show ldp inter-area-fecs
LSR codes : E/N - LSR is egress/non-egress for this FEC,
L - LSR received a label for this FEC,
> - LSR will use this route for the FEC
Code FEC Session Out Label Nexthop Addr
Matching RIB prefix - 1.1.1.0
NL> 1.1.1.1/32 33.33.33.33 52485 11.11.11.1
NL> 1.1.1.2/32 33.33.33.33 52486 11.11.11.1

#show ldp inter-area-fecs count
------------------------
Num. IPv4 FEC(s) : 9
------------------------
------------------------
Num. IPv6 FEC(s) : 0
------------------------
------------------------
Total Num. FEC(s): 9
------------------------

#show ldp inter-area-fecs ipv4 count
------------------------
Num. IPv4 FEC(s) : 9
------------------------

#show ldp inter-area-fecs ipv6 count
------------------------
```

```
Num. IPv6 FEC(s) : 0
------------------------
```

show ldp inter-area-fecs prefix

Use this command to show all LDP inter-area FECs by prefix.

Use parameter count to show FEC count for each prefix.

Command Syntax

```
show ldp inter-area-fecs prefix (A.B.C.D/M|X:X::X:X/M) count
```

Parameter

`A.B.C.D/M`	IP prefix <network>/<length>, e.g., 35.0.0.0/8
`X:X::X:X/M`	IPv6 prefix <network>/<length>, e.g., 3ffe::/16
`count`	Count of FECs

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.1.

Examples

```
#show ldp inter-area-fecs prefix 4.4.4.0/30
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                     Code    Session         Out Label       ELC     Nexthop Addr
Matching RIB prefix - 4.4.4.0/30
4.4.4.1/32               NL>     1.1.1.1          24970            No      12.1.1.1
                         NL>     3.3.3.3          24329            No      23.1.1.2
4.4.4.2/32               NL>     1.1.1.1          24971            No      12.1.1.1
                         NL>     3.3.3.3          24330            No      23.1.1.2
4.4.4.3/32               NL>     1.1.1.1          24972            No      12.1.1.1
                         NL>     3.3.3.3          24331            No      23.1.1.2

#show ldp inter-area-fecs prefix 4.4.4.0/30 count
Matching RIB prefix - 4.4.4.0/30
------------------------
Num. IPv4 FEC(s): 3
------------------------

#show ldp inter-area-fecs prefix 3ffe::/16
LSR codes    : E/N - LSR is egress/non-egress for this FEC,
               L - LSR received a label for this FEC,
               > - LSR will use this route for the FEC
FEC                     Code    Session         Out Label       ELC     Nexthop Addr

#show ldp inter-area-fecs prefix 3ffe::/16 count
```

show ldp interface

Table 2-8: show ldp fec output fields details

Field	Description
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Session	Reports the current session state.
Out Label	Label received from downstream neighbor for route.
Nexthop addr	Displays the IP address of the next hop.

Use this command to display the list of all interfaces on the current LSR, and to indicate whether a given interface is label-switching or not.

Command Syntax

```
show ldp interface
show ldp interface IFNAME
```

Parameter

`IFNAME` Displays the name of the interface.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The following output displays a list of all interfaces on the LSR.

```
#show ldp interface
InterfaceLDP IdentifierLabel-switchingMerge Capability
eth010.10.0.11:0DisabledN/A
lo10.10.0.11:0DisabledN/A
eth110.10.0.11:0Enabled Merge capable
eth210.10.0.11:0Enabled Merge capable
vmnet1 10.10.0.11:0Disabled N/A
```

The following is a sample output from the `show ldp interface IFNAME` command displaying information about the specified interface `eth1`.

```
#show ldp interface eth1
Status                   : Enabled
Primary IP Address       : 192.168.3.4
Interface Type           : Ethernet
Label Merge Capability   : Merge Capable
Hello Interval           : 5
Targeted Hello Interval  : 15
Hold Time                : 15
Targeted Hold Time       : 45
```

```
Keepalive Interval      : 10
Keepalive Timeout       : 30
Advertisement Mode      : Downstream On Demand
Label Retention Mode    : Liberal
Administrative Groups   : myGroup
```

Table 2-9 explains the show command output fields.

Table 2-9: show ldp interface output fields details

Field	Description
Interface	Name of the interface.
LDP Identifier	LDP identifier for this protocol.
Label-switching	Status of the label-switching on interface..
Merge Capability	Used to override the default merge capability setting of all the interfaces.
Status	Status of the ldp interface.
Primary IP Address	Address of the primary Internet protocol in the interface.
Interface Type	Type of interface.
Label Merge Capability	Used to override the default merge capability setting of all the interfaces for the label.
Hello Interval	Sets the interval for sending unicast hello packets to peers.
Targeted Hello Interval	Sets the interval for sending unicast hello packets to targeted peers.
Hold time	Sets the time-out value to peers.
Targeted Hold time	Sets the time-out value that is the time that the router waits before rejecting an adjacency with targeted peers.
Keepalive Interval	Used to set the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Label Advertisement Mode	Used to set the label advertisement mode for an interface for the current LSR to either downstream-on-demand (label is sent only when requested) or downstream-unsolicited (label is sent unrequested).
Label Retention Mode	Used for all labels exchanged via the given interface.
Administrative Groups	Administrative group to be used for links.

show ldp lsp

Use this command to display LDP LSP and, optionally, advertise-label information.

Command Syntax

```
show ldp lsp
show ldp lsp prefix detail
show ldp lsp (prefix|detail)
```

Parameter

`prefix`	Displays advertise-label information in addition to LDP LSP information.
`detail`	Displays advertise-label information in addition to LDP LSP information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3. and was updated in OcNOS version 5.1.

Example

The following is a sample output from the `show ldp lsp prefix detail` command displaying LDP LSP prefix information with advertise-label information.

When LDP LFA FRR in not enabled:

```
#show ldp lsp
DOWNSTREAM LSP :
  FEC                 Nexthop Addr   State           Label     Req.ID    Attr
  10.0.1.0/31         connected       Established     impl-null  0
  10.0.1.0/31        connected        Established      none      0         None
  10.0.2.0/31         connected      Established      24322     0
  10.0.2.0/31         10.0.1.1        Established      impl-null  0
  10.0.3.0/31         connected      Established      24323     0
  10.0.3.0/31         10.0.4.1       Established     impl-null   0
  10.0.4.0/31         connected      Established     impl-null   0
  10.0.4.0/31        connected        Established     none       0         None
  11.1.1.1/32        connected        Established     none       0         None
  22.1.1.1/32         10.0.1.1       Established      impl-null  0
  33.1.1.1/32         10.0.4.1        Established      24323      0
  33.1.1.1/32         10.0.1.1        Established      24324      0
  44.1.1.1/32         10.0.4.1        Established      impl-null  0
  192.168.254.0/24   connected       Established      impl-null   0
  192.168.254.0/24   connected       Established       impl-null  0
   192.168.254.0/24   connected      Established      none        0       None


    UPSTREAM LSP :
```

```
      FEC                   State              Label        Req.ID       Attr
      10.0.1.0/31           Established        impl-null    0            None
      10.0.1.0/31           Established        impl-null    0            None
      10.0.2.0/31           Established        24320        0            None
      10.0.3.0/31           Established        24321        0            None
      10.0.4.0/31           Established        impl-null    0            None
      10.0.4.0/31           Established        impl-null    0            None
      11.1.1.1/32           Established        impl-null    0            None
      11.1.1.1/32           Established        impl-null    0            None
      22.1.1.1/32           Established        24322        0            None
      44.1.1.1/32           Established        24324        0            None
      192.168.254.0/24      Established        impl-null    0            None
      192.168.254.0/24      Established        impl-null    0            None
```

When LDP LFA FRR in enabled:

```
    #show ldp lsp
    DOWNSTREAM LSP :
  FEC               Nexthop Addr    State          Label        Req.ID     Attr      Code
  10.0.1.0/31        connected     Established    impl-null     0
  10.0.1.0/31        connected     Established    none          0       None
  10.0.2.0/31        connected     Established     24322        0
  10.0.2.0/31        10.0.4.1      Established    24322         0                     B
  10.0.2.0/31        10.0.1.1      Established    impl-null     0                     P
  10.0.3.0/31        connected     Established    24323         0
  10.0.3.0/31        10.0.1.1      Established    24323         0                     B
  10.0.3.0/31        10.0.4.1      Established    impl-null     0                     P
  10.0.4.0/31        connected     Established    impl-null    0
  10.0.4.0/31       connected     Established     none         0          None
  11.1.1.1/32       connected     Established     none         0          None
  22.1.1.1/32          10.0.1.1    Established    impl-null     0                     P
  33.1.1.1/32          10.0.4.1    Established    24323         0                     P
  33.1.1.1/32          10.0.4.1    Established    24323         0                     B
  33.1.1.1/32          10.0.1.1    Established    24324         0                     P
  33.1.1.1/32          10.0.1.1    Established    24324         0                     B
  44.1.1.1/32          10.0.4.1    Established    impl-null     0
  192.168.254.0/24    connected    Established    impl-null    0
  192.168.254.0/24    connected    Established    impl-null    0
  192.168.254.0/24    connected    Established     none        0          None

UPSTREAM LSP :
  FEC                State             Label        Req.ID       Attr
  10.0.1.0/31        Established       impl-null    0            None
  10.0.1.0/31        Established       impl-null    0            None
  10.0.2.0/31        Established       24320        0            None
  10.0.3.0/31        Established       24321        0            None
  10.0.4.0/31        Established       impl-null    0            None
  10.0.4.0/31        Established       impl-null    0            None
  11.1.1.1/32        Established       impl-null    0            None
  11.1.1.1/32        Established       impl-null    0            None
  22.1.1.1/32        Established       24322        0            None
```

```
44.1.1.1/32        Established      24324       0           None
192.168.254.0/24   Established      impl-null   0           None
192.168.254.0/24   Established      impl-null   0           None
```

Table 2-10 explains the show command output fields.

Table 2-10: show ldp lsp output fields details

Field	Description
Session peer	Used to group and apply the configuration of general session commands to groups of neighbors that share common session configuration elements.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
Nexthop addr	Displays the IP address of the next hop.
State	Displays the current status of the ldp.
Label	Details of the ldp downstream labels.
Req.ID	Request identifier for the protocol.
Attr	The attribute is used to sent to a customer router.
Code	Show if an entry is principal or backup.

show ldp mpls-l2-circuit

Use this command to display summarized Layer-2 Virtual Circuit information about all MPLS virtual circuits configured on the current LSR. When the Virtual Circuit ID is specified, this command displays summarized information for the Virtual Circuit matching the specified ID only.

Command Syntax

```
show ldp mpls-l2-circuit

show ldp mpls-l2-circuit <1-4294967295>

show ldp mpls-l2-circuit detail

show ldp mpls-l2-circuit count

show ldp mpls-l2-circuit <1-4294967295> detail
```

Parameter

`<1-4294967295>`	Indicates the virtual circuit ID.
`detail`	Displays detailed LDP information.
`count`	Count of PWs from LDP standpoint.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output of this command displaying summarized information of VID 1000:

```
#show ldp mpls-l2-circuit 1000
Transport Client     VC     Trans    Local        Remote       Destination
VC ID     Binding    State  Type     VC Label     VC Label     Address
1000      eth2       UP     ethernet 640          640          192.168.0.80

#show ldp mpls-l2-circuit
Transport Client     VC     Trans    Local        Remote       Destination
VC ID     Binding    State  Type     VC Label     VC Label     Address
1000      eth2       UP     ethernet 640          640          192.168.0.80
2000      eth3       UP     ethernet 641          648          192.168.0.80
3000      eth4       UP     ethernet 642          645          192.168.0.90
```

The following is a sample output of this command when using the `detail` parameter:

```
#show ldp mpls-l2-circuit detail
vcid: 100, type: ethernet, local groupid: 4, remote groupid: 4 (vc is up)
destination: 10.0.0.2, Peer LDP Ident: 10.0.0.2
Local label: 53120, remote label: 53120
Access IF: eth3, Network IF: eth4
Local MTU: 1500, Remote MTU: 1500
Local Control Word: 0, Remote Control Word: 0
Local PW Status Capability : enabled
```

```
Remote PW Status Capability : enabled
Current PW Status TLV : enabled
Local PW Status :
Not Forwarding
Remote PW Status :
Not Forwarding
Standby
```

Table 2-11 explains the show command output fields.

Table 2-11: show ldp mpls-l2-circuit output fields details

Field	Description
Transport VC ID	Transport VC identifier for the protocol.
Client Binding	Show whether the interface is client bound and (if bound) with which client.
VC State	State of the VC.
Trans Type	Type of transmit.
Local VC Label	Incoming VC label details.
Remote VC Label	Outgoing VC label details.
Destination Address	Destination IP address for the protocol.
VCid	Address for the VC.
Type	Type of Ethernet interface.
local groupid	Address for the local group.
remote groupid	Address for the remote group.
destination	Destination IP address.
Peer LDP Ident	Identification for the peer LDP.
Local label	Number of Local label
remote label	Number remote label.
Access IF	Map the access port.
Network IF	Map the network port in the interface.
Local MTU	Number of local MTU., Remote MTU - Number of local MTU.
Local Control Word	Number of local control word.
Remote Control Word	Number of local control word.
Local PW Status Capability	PW Status capability of Local end of PW.

Table 2-11: show ldp mpls-l2-circuit output fields details (Continued)

Field	Description
Remote PW Status Capability	PW Status capability of Remote end of PW.
Current PW Status TLV	A data structure used to encode optional information in a data communications protocol.
Local PW Status	PW Status of Local end of PW.
Remote PW Status	PW Status of Remote end of PW.

show ldp rlfa-routes

Use this command to display LDP remote LFA routes.

Command Syntax

```
show ldp rlfa-routes
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#show ldp rlfa-routes
Fec             Primary-NH     Backup-NH     rLFA-Addr     Out-Intf  Outer-
label  Inner-label
2.2.2.2          20.1.1.1        30.1.1.1        1.1.1.1         xe5
24320       24324
3.3.3.3          30.1.1.1        20.1.1.1        1.1.1.1         xe12
24320       24325
```

show ldp routes

Use this command to display LDP routes.

Command Syntax

```
show ldp routes
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3 and was updated in OcNOS version 5.1.

Example

```
When LDP LFA FRR in not enabled:

#show ldp routes
Prefix Addr         Nexthop Addr     Intf
10.0.1.0/31         0.0.0.0          eth2
10.0.2.0/31         10.0.1.1         eth2
                    10.0.4.1         eth1
10.0.3.0/31         10.0.4.1         eth1
                    10.0.1.1         eth2
10.0.4.0/31         0.0.0.0          eth1
11.1.1.1/32         0.0.0.0          lo
22.1.1.1/32         10.0.1.1         eth2
33.1.1.1/32         10.0.1.1         eth2
                    10.0.4.1         eth1
44.1.1.1/32         10.0.4.1         eth1
192.168.254.0/24    0.0.0.0          eth0

When LDP LFA FRR in enabled:

#show ldp routes
Prefix Addr         Nexthop Addr     Intf        Backup Addr      Backup Intf
10.0.1.0/31         0.0.0.0          eth2        -                -
10.0.2.0/31         10.0.1.1         eth2        10.0.4.1         eth1
10.0.3.0/31         10.0.4.1         eth1        10.0.1.1         eth2
10.0.4.0/31         0.0.0.0          eth1        -                -
11.1.1.1/32         0.0.0.0          lo          -                -
22.1.1.1/32         10.0.1.1         eth2        -                -
33.1.1.1/32         10.0.1.1         eth2        10.0.4.1         eth1
                    10.0.4.1         eth1        10.0.1.1         eth2
44.1.1.1/32         10.0.4.1         eth1        -                -
192.168.254.0/24    0.0.0.0          eth0        -                -
```

Table 2-12 explains the show command output fields.

Table 2-12: show ldp routes output fields details

Prefix Addr	Details of the network address prefix.
Nexthop Addr	Displays the IP address of the next hop.
Intf	Displays an interface name.
Backup Addr	Displays the IP address of the backup next hop.
Backup Intf	Displays a backup interface name.

show ldp session

Use this command to display sessions established between this LSR and other LSRs.

Command Syntax

```
show ldp session
show ldp session A.B.C.D
show ldp session X:X::X:X
show mpls ldp session
show mpls ldp session A.B.C.D
show mpls ldp session X:X::X:X
```

Parameter

`A.B.C.D`	IPv4 address of the peer.
`X:X::X:X`	IPv6 address of the peer.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
OcNOS#show ldp session 192.168.3.5
Session state: OPERATIONAL
Session role: Passive
TCP Connection: Established
IP Address for TCP: 192.168.3.5
Interface being used : eth1
Peer LDP ID: 10.10.0.18:0
Peer Password : mypwd
Authentication type: MD5
Adjacencies: 192.168.3.5
192.168.4.5
Advertisement mode: Downstream Unsolicited
Label retention mode : Liberal
Graceful Restart             : Capable
Reconnect Timeout            : 120
Recovery Timeout (max)       : 120
Recovery Timeout [negotiated] : 0 [120]
Keepalive Timeout: 30
Reconnect Interval: 15
Address List received : 192.168.3.5
192.168.4.5
Received Labels :FecLabelMaps To
IPV4:10.10.0.0/24
impl-null none
IPV4:192.168.3.0/24 impl-null none
IPV4:192.168.4.0/24 impl-null none
```

```
IPV4:192.168.5.0/24 impl-null none
Sent Labels :FecLabelMaps To
IPV4:10.10.0.0/24
impl-null none
IPV4:192.168.3.0/24 impl-null none
IPV4:192.168.4.0/24 impl-null none
```

Table 2-13 explains the show command output fields.

Table 2-13: show ldp session output fields details

Field	Description
Session state	Reports the current session state.
Session role	Displays the status of the session role.
TCP Connection	Details of the TCP connection.
IP Address for TCP	Transmission control protocol IP address for the network.
Interface	Name of interface used in the network.
Peer LDP ID	Identifier for the peer LDP.
Peer Password	Credential details for the neighbor.
Authentication type	Type of authentication.
Adjacencies	IP address for the neighbor adjacencies.
Advertisement mode	Details of the advertisement mode.
Label retention mode	Details of the label retention mode.
Graceful Restart	Indicates if the peer session is “Capable” or “Not Capable”.
Reconnect Timeout	The amount of time the router keeps the labels until session re-connection, the value is the lower value between local and remote neighbor-liveness timer. It appears when the session is GR capable.
Recovery Timeout (max)	Indicates the amount of time for the recovery session to send the initialization message to the peer, according to the local max-recovery timer. It appears when the session is GR capable.
Recovery Timeout [negotiated]	Indicates the actual timer value and the initial amount of time to recovery session (between brackets) that is negotiated with the peer to the lower value between local and remote values. Negotiated value 0 indicates the labels are not preserved after session disconnection. It appears when the session is GR capable.
Keepalive Interval	Used to set the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Address List received	List of address that is received from neighbor.
Received Labels	Number of labels received from neighbor session.
Sent Labels	Number of labels transmitted to neighbor session.

show ldp statistics

Use this command to display LDP statistics.

Command Syntax

```
show ldp statistics
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp statistics` command.

```
#show ldp statistics

=======================================================
 LSR ID = 0.0.0.0:0 : TARGETED PEER: 10.10.10.10
=======================================================
  PacketType                      Total
                             Sent        Received
  Notification                 0            0
  Hello                        0            0
  Initialization               0            0
  Keepalive                    0            0
  Address                      0            0
  Address Withdraw             0            0
  Label Mapping                0            0
  Label Request                0            0
  Label Withdraw               0            0
  Label Release                0            0
  Request Abort                0            0
=======================================================
#
```

Table 2-14 explains the show command output fields.

Table 2-14: show ldp statistics output fields details

Field	Description
LSR ID	Identifier of the LSR.
Targeted Peer	Targeted LDP neighbor can improve the label convergence time compared to the convergence time with directly connected LDP peers when there are flapping links.

Table 2-14: show ldp statistics output fields details (Continued)

Field	Description
Packet Type	Type of packet in the interface that has been received or transmitted to the neighbors.
Total	Number of total packets that has been received and transmitted.

show ldp statistics advertise-labels

Use this command to display the count per each operation filtered by an advertisement list.

Command Syntax

```
show ldp statistics advertise-labels
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp statistics advertise-labels` command.

```
#show ldp statistics advertise-labels
Advertisement spec:
    Prefix list = pfx1; Peer plist = pfx1
      Deny : Label Mapping = 2
             Label Request = 0
    Prevent the distribution of any assigned labels
      Deny : Label Mapping = 9
             Label Request = 3
#
```

Table 2-15 explains the show command output fields.

Table 2-15: show ldp statistics advertise-labels output fields details

Field	Description
Advertisement spec	Details of the advertisement spec.
Prefix list	It is an ordered list and entries are evaluated in order of increasing sequence number.
Peer plist	The peer keyword enables the device to receive time requests and used to synchronize itself to the servers specified in the access list.
Label Mapping	Number of label mapping that is denied.
Label Request	Number of label request that is denied.

show ldp targeted-peers

Use this command to display the list of targeted peers configured on the current LSR.

Command Syntax

```
show ldp targeted-peers
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output from the `show ldp targeted-peers` command.

```
#show ldp targeted-peers
IP Address          Interface

192.168.201.2       eth1
```

Table 2-16 explains the show command output fields.

Table 2-16: show ldp targeted-peers output fields details

Field	Description
IP Address	Internet protocol address for the interface.
Interface	Name of the interface.

show ldp upstream

Use this command to display the status of all upstream sessions and label information exchanged.

Command Syntax

```
show ldp upstream
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output of the `show ldp upstream` command showing the status of all upstream sessions.

```
#show ldp upstream
Session peer 1.1.1.1:
  FEC                           State                Label     Req.ID    Attr
  60.0.0.0/24                 Established            52486        0      None
  4.4.4.4/32                  Established            52484        0      None
  50.0.0.0/24                 Established            52483        0      None
  40.0.0.0/24                 Established        impl-null        0      None
  30.0.0.0/24                 Established        impl-null        0      None
  20.0.0.0/24                 Established        impl-null        0      None
  10.0.2.0/24                 Established        impl-null        0      None
  5.5.5.5/32                  Established            52482        0      None
  3.3.3.3/32                  Established            52481        0      None
  2.2.2.2/32                  Established        impl-null        0      None
Session peer 3.3.3.3:
  FEC                           State                Label     Req.ID    Attr
  60.0.0.0/24                 Established            52487        0      None
  4.4.4.4/32                  Established            52485        0      None
  1.1.1.1/32                  Established            52480        0      None
  40.0.0.0/24                 Established        impl-null        0      None
  30.0.0.0/24                 Established        impl-null        0      None
  20.0.0.0/24                 Established        impl-null        0      None
  10.0.2.0/24                 Established        impl-null        0      None
  2.2.2.2/32                  Established        impl-null        0      None
Session peer 4.4.4.4:
  FEC                           State                Label     Req.ID    Attr
  50.0.0.0/24                 Established            52483        0      None
  40.0.0.0/24                 Established        impl-null        0      None
  30.0.0.0/24                 Established        impl-null        0      None
  20.0.0.0/24                 Established        impl-null        0      None
  10.0.2.0/24                 Established        impl-null        0      None
  3.3.3.3/32                  Established            52481        0      None
  2.2.2.2/32                  Established        impl-null        0      None
  1.1.1.1/32                  Established            52480        0      None
```

Table 2-17 explains the show command output fields.

Table 2-17: show ldp upstream output fields details

Field	Description
Session peer	Details of the session peers.
FEC	Displays the Forward Equivalency Class (FEC) for this entry.
State	Reports the current session state.
Label	Number of Label received from upstream neighbor for route.
Req.ID	Requested session identifier for the protocol.
Attr	The attribute is used to sent packets to a customer router.

show ldp vpls

Use this command to display information about all VPLS instances. Specify the VPLS ID to display information about a specific VPLS instance.

Command Syntax

```
show ldp vpls <1-4294967295> (count|)
show ldp vpls count
show ldp vpls detail
show ldp vpls (no-vc|)
```

Parameter

`<1-4294967295>`	Display the VPLS identifier.
`count`	Display VPLS count from LDP standpoint.
`detail`	Display detailed LDP VPLS information.
`no-vc`	Specify not display L2VC information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The following is a sample output of the `show ldp vpls` command displaying information about all VPLS instances.

```
#show ldp vpls
VPLS-ID      Peer Address       State  Type        Label-Sent   Label-Rcvd
1            192.168.0.80       Up     vpls        16           640
1            192.168.0.90       Up     vpls        18           642
2            192.168.0.80       Up     vpls        19           641
2            192.168.0.90       Up     vpls        17           643
```

The following is an output of the `show ldp vpls detail` command:

```
#show ldp vpls detail
 VPLS Identifier    : 1
 Peer IP            : 192.168.0.80
 VC State           : UP
 VC Type            : vpls
 VC Label Sent      : 16
 VC Label Received  : 640

 VPLS Identifier    : 1
 Peer IP            : 192.168.0.90
 VC State           : UP
 VC Type            : vpls
 VC Label Sent      : 18
 VC Label Received  : 642
```

```
VPLS Identifier    : 2
Peer IP            : 192.168.0.80
VC State           : UP
VC Type            : vpls
VC Label Sent      : 19
VC Label Received  : 641
```

The following is a sample output of `show ldp vpls count` displaying information about total, active and inactive VPLS instances from LDP.

```
#show ldp vpls count
-------------------------------
Total VPLS instances    : 2
Active VPLS instances   : 2
Inactive VPLS instances : 0
-------------------------------
```

Table 2-18 explains the show command output fields.

Table 2-18: show ldp vpls output fields details

Field	Description
VPLS-ID	Identification details of the VPLS.
Peer Addr	IP address of the peer device.
State	Reports the current session state.
Type	Type of protocol in network.
Label-Sent	Number of packets transmitted to neighbor.
Label-Rcvd	Number of packets received from neighbor.
Total VPLS instances	Number of total VPLS instance in the protocol.
Active VPLS instances	Number of active VPLS instance.
Inactive VPLS instances	Number of inactive VPLS instance.

show mpls ldp discovery

Use this command to display the sources for locally generated LDP Discovery Hello PDUs, and to indicate whether an interface is label-switching.

Command Syntax

```
show mpls ldp discovery
show mpls ldp discovery IFNAME
```

Parameter

IFNAME	Interface name.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ldp discovery
InterfaceLDP IdentifierLabel-switchingMerge Capability
eth010.10.0.11:0DisabledN/A
lo10.10.0.11:0DisabledN/A
eth110.10.0.11:0Enabled Merge capable
eth210.10.0.11:0Enabled Merge capable
vmnet110.10.0.11:0  Disabled N/A
```

Table 2-19 explains the show command output fields.

Table 2-19: show ldp discovery output fields details

Field	Description
Interface	Name of the interface.
LDP Identifier	LDP identifier for this protocol.
Label-switching	Status of the label-switching on interface.
Merge Capability	Used to override the default merge capability setting of all the interfaces.

show mpls ldp neighbor

Use this command to display LDP neighbor information.

Command Syntax

```
show mpls ldp neighbor
show mpls ldp neighbor detail
```

Parameter

detail	Details for adjacencies.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ldp neighbor detail
IP AddressInterface NameHoldtimeLDP ID
192.168.3.5eth11510.10.0.18:0
192.168.4.5eth21510.10.0.18:0
```

Table 2-20 explains the show command output fields.

Table 2-20: show mpls ldp neighbor output fields

Field	Description
IP Address	Address of the interface.
Interface Name	Name of the interface.
Holdtime	The amount of time this device waits between SPFs.
LDP ID	Local label space ID. The first four bytes of an LDP ID is a platform IP address called the LDP router ID. The last two bytes are called the local label space ID.

show mpls ldp parameter

Use this command to display LDP configuration parameters.

Command Syntax

```
show mpls ldp parameter
```

Parameter

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show mpls ldp parameter
Router ID                    : 0.0.0.0
LDP Version                  : 1
Global Merge Capability      : Merge Capable
Label Advertisement Mode : Downstream Unsolicited
Label Retention Mode         : Liberal
Label Control Mode           : Independent
Instance Loop Detection      : Off
Request Retry                : Off
Propagate Release            : Disabled
Graceful Restart             : Disabled
Hello Interval               : 5
Targeted Hello Interval      : 15
Hold time                    : 15
Targeted Hold time           : 45
Keepalive Interval           : 10
Keepalive Timeout            : 30
Request retry Timeout        : 5
Transport Address data       :
  Labelspace 0               : 192.168.201.2 (not in use)
Import BGP routes            : No
```

Table 2-21 explains the show command output fields.

Table 2-21: show mpls ldp parameters output fields

Field	Description
Router ID	A preferred interface address for LDP router.
LDP Version	Latest LDP version details.

Table 2-21: show mpls ldp parameters output fields

Field	Description
Global Merge Capability	Override the default merge capability setting of all the interfaces.
Label Advertisement mode	Label advertisement mode details in the interface.
Label retention mode	Label retention mode details in the interface.
Label Control Mode	Controls the mode used for handling label binding requests on interfaces.
Instance Loop Detection	Disables the LDP optional loop detection mechanism.
Request Retry	Request causes the target peer to respond with targeted Hello messages.
Propagate Release	Propagate release is disabled in the interface.
Graceful Restart	Graceful Restart (GR) is a mechanisms to prevent routing protocol re-convergence during a processor switchover. Hello Interval - Hello interval sets the interval for sending unicast hello packets to peers.
Targeted Hello Interval	Targeted hello interval sets the interval for sending unicast hello packets to targeted peers.
Hold time	Hold time sets the time-out value to peers.
Targeted Hold time	Time-out value is the time that the router waits before rejecting an adjacency with targeted peers.
Keepalive Interval	Keepalive interval sets the interval for sending keep-alive messages to the peer in order to maintain a session.
Keepalive Timeout	Time-out value for rejecting a session with a peer.
Request retry Timeout	Request for the maximum retry duration (the number of retries times the length of the timeout).
Transport Address data	Transport address advertised in LDP Discovery Hello messages sent on an interface.
Label space	Label used in a label binding is allocated from a set of possible labels called a label space.
Import BGP routes	The BGP Support for IP Prefix Import from Global Table into a VRF Table feature introduces the capability to import IPv4 unicast prefixes from the global routing table into a Virtual Private Network (VPN) routing/forwarding (VRF) instance table using an import route map.

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Resource Reservation Protocol Configuration

CHAPTER 1 RSVP-TE Configuration

This chapter contains configurations for Resource Reservation Protocol - Traffic Engineering (RSVP-TE).

RSVP-TE Overview

RSVP-TE is a signaling protocol that supports explicit routing capabilities, To do this, an Explicit Route (ER) object is incorporated into RSVP PATH messages. This object encapsulates a sequence of hops that constitute the explicitly-routed path. Using the ER object, the paths taken by label-switched RSVP-MPLS flows can be pre-determined without conventional IP routing. An ER path can be administratively specified or computed based on CSPF and any policy requirements dictated by the operator through the trunk node, taking the current network state into consideration. A useful application of explicit routing is Traffic Engineering (TE). Using explicitly-routed LSPs, an ingress node can control the path through which traffic flows from itself, through the MPLS network, to the egress node. Explicit routing is therefore useful for the optimization of network resources and an increase in the quality of traffic-oriented performance.

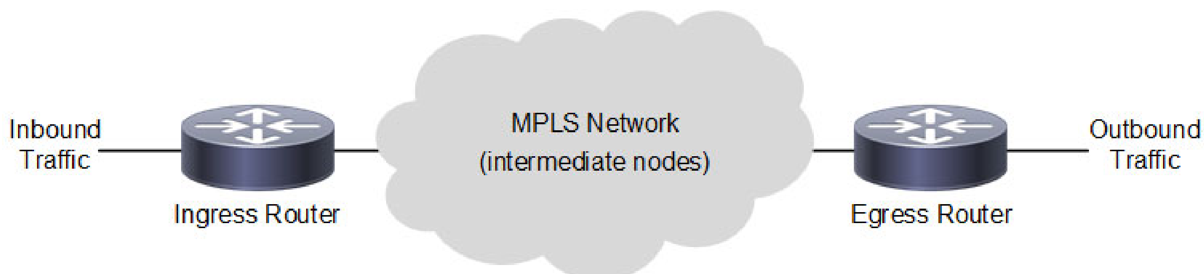

Figure 1-11: Basic RSVP-TE Topology

RSVP-TE Architecture

RSVP-TE is a signaling protocol that supports explicit routing capabilities to establish LSPs in a MPLS network. OcNOS RSVP-TE:

- Creates explicitly-routed paths, which might not agree with the route suggested by the IGP (OSPF, RIP) being used. Explicitly-routed LSPs, by definition, do not follow the paths suggested by IGPs.
- Queries CSPF for a complete, end-to-end, explicit route based on constraints specified by the operator using RSVP commands.
- Performs make-before-break type re-routing of tunnels. (Make-before-break is the creation of a new LSP before the old one is torn down).
- Exchanges Hello messages to make node failures easier to detect. This means when there is no hello exchange between routers, then other node is assumed dead or offline (except in the case when the peer is known to not support Hellos).
- Provides statistical information of RSVP messages exchanged.

In addition, OcNOS RSVP-TE may be used in unison with BGP to generate MPLS/BGP VPNs, and in unison with LDP to generate Layer-2 Virtual Circuits.

Configure RSVP-TE

Note: The following configuration for establishing a trunk is required on all routers participating in label-switching. Based on the assumption that minimal configurations exist on all participating routers, other examples do not repeat this configuration.

Enable Label Switching - Minimal Configuration

To establish a trunk on a system:

1. Enable label-switching and RSVP-TE on all participating interfaces.
2. Configure a trunk on the ingress router to use the best available IGP path.

   In this example, the Label Switched Path (LSP) is configured using minimal configuration and is setup using the best IP nexthop available. Each router along the path is chosen by the previous router by looking up the best nexthop available in its IP routing table.

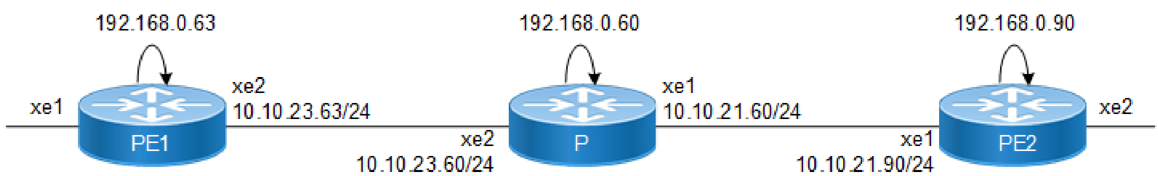

Figure 1-12: Topology for Minimal Configuration

PE1 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 192.168.0.63/32 secondary	Set the IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter interface mode.
(config-if)#ip address 10.10.23.63/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface xe2.
(config-if)#commit	Commit the transaction.

PE1 - RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe2	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

PE1 - OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and specify the Process ID `(100)`. The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#router-id 192.168.0.63`	Configure OSPF router-ID same as loopback interface IP address
`(config-router)#network 10.10.23.0/24 area 0`	Define the network `(10.10.23.0/24)` on which OSPF runs and associate the area ID `(0)`.
`(config-router)#network 192.168.0.63/32 area 0`	Set the IP address of the loopback interface to `192.168.0.63/32`.
`(config-router)#commit`	Commit the transaction.

P - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 192.168.0.60/32 secondary`	Set the IP address for the interface.
`(config-if)#exit`	Enable label switching on interface `lo`.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#ip address 10.10.23.60/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `xe2`.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.21.60/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `xe1`.
`(config-if)#commit`	Commit the transaction.

P - RSVP-TE

`(config)#router rsvp`	Enter `Configure Router` mode.
`(config-router)#exit`	Exit `Router` mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#commit`	Commit the transaction.

P - OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and specify the Process ID (`100`). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#router-id 192.168.0.60`	Configure OSPF router-ID same as loopback interface IP address
`(config-router)#network 10.10.23.0/24 area 0`	Define the first network (`10.10.23.0/24`) on which OSPF runs and associate the area ID (`0`).
`(config-router)#network 10.10.21.0/24 area 0`	Define the second network (`10.10.21.0/24`) on which OSPF runs and associate the area ID (`0`).
`(config-router)#network 192.168.0.60/32 area 0`	Set the IP address of the loopback interface to `192.168.0.63/32`.
`(config-router)#commit`	Commit the transaction.

PE2 - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 192.168.0.90/32 secondary`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.21.90/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `xe2`.
`(config-if)#commit`	Commit the transaction.

PE2 - RSVP-TE

`(config)#router rsvp`	Enter `Configure Router` mode.
`(config-router)#exit`	Exit `Router` mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#commit`	Commit the transaction.

PE2 - OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and specify the Process ID (`100`). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#router-id 192.168.0.90`	Configure OSPF router-ID same as loopback interface IP address

(config-router)#network 10.10.21.0/24 area 0	Define the network (10.10.21.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 192.168.0.90/32 area 0	Set the IP address of the loopback interface to 192.168.0.63/32.
(config-router)#commit	Commit the transaction.

Establish a Trunk with CSPF Disabled

OcNOS, Constrained Shortest Path First (CSPF) calculation is enabled by default.Typically, CSPF is disabled when all of the participating nodes do not support the required traffic engineering extensions and LSPs are configured manually to use an explicit path. In this case, an LSP is established only along the path specified by the operator.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in Enable Label Switching - Minimal Configuration.

Topology

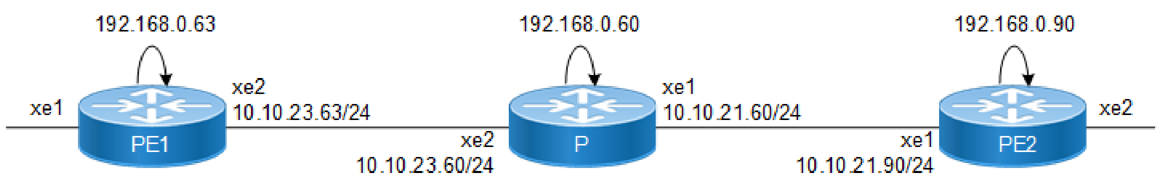

Figure 1-13: Basic Topology

PE1 - RSVP-TE

#configure terminal	Enter configure mode.
(config)#rsvp-trunk T1	Create an RSVP trunk T1 and enter the Trunk mode.
(config-trunk)#no primary cspf	Specify no primary cspf since CSPF is enabled by default.
(config-trunk)#to 192.168.0.90	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

Establish a Trunk Using CSPF

The RSVP trunk can be configured using CSPF (Constraint-based Shortest Path First). In this case, the RSVP daemon (rsvpd) sends a request to the CSPF server to compute a path through the network to reach the destination. CSPF returns a hop-by-hop path called the Explicit Route to the RSVP daemon to be used in the Explicit Route Object (ERO). Each router along the path sends a `Path` message only to the nexthop specified in the ERO. In the OcNOS implementation, CSPF is enabled by default and if `no cspf` is not specified, the trunk is CSPF enabled automatically.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in Enable Label Switching - Minimal Configuration.

PE1 (RSVP Daemon)

#configure terminal	Enter configure mode.
(config)#rsvp-trunk T1	Create an RSVP trunk T1 and enter the Trunk mode.

`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#commit`	Commit the transaction.

Mapping a Route to a Trunk

In the OcNOS implementation, a network can be mapped to a particular trunk using map-route configuration.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers. For configuration details, refer to the “Establishing a Trunk - Minimal Configuration” section.

Topology

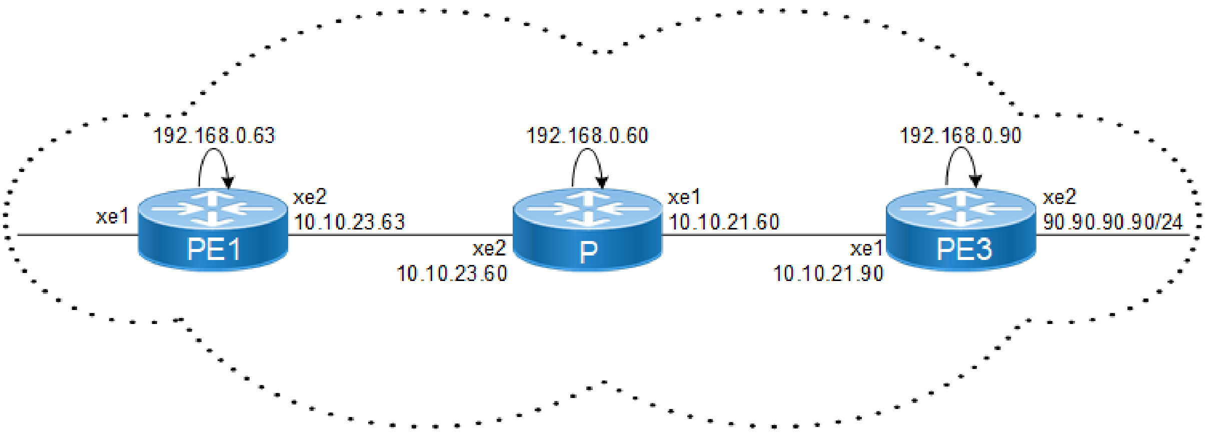

Figure 1-14: Topology for route mapping

PE1 - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#router rsvp`	Enable RSVP globally.
`(config-router)#rsvp-path PE2`	Configure RSVP path.
`(config-path)#rsvp-trunk T1`	Create an RSVP trunk T1 and enter the Trunk mode.
`(config-trunk)#map-route 90.90.90.0/24`	Specify the destination prefix that needs to mapped to this trunk.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#commit`	Commit the transaction.

Establish a Trunk Using Explicitly-Defined Path

Explicit Route hops can be configured manually in the trunk configuration. In this case, the RSVP daemon uses the configured hops as Explicit Route Objects (ERO). It sets up the LSP using specified hops only.

An ERO is composed of IP addresses called hops. An ERO hop can be defined as loose or strict. A loose hop can be reached by any available route. A strict hop must be reached via a direct link and cannot be routed over any alternate routers in between. In this example, since PE3 is defined as loose hop, P can use P2 as an intermediate hop to reach PE2. However, if it was a strict hop, then P would have to use interface `xe1` to reach PE3 directly.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in Enable Label Switching - Minimal Configuration.

Topology

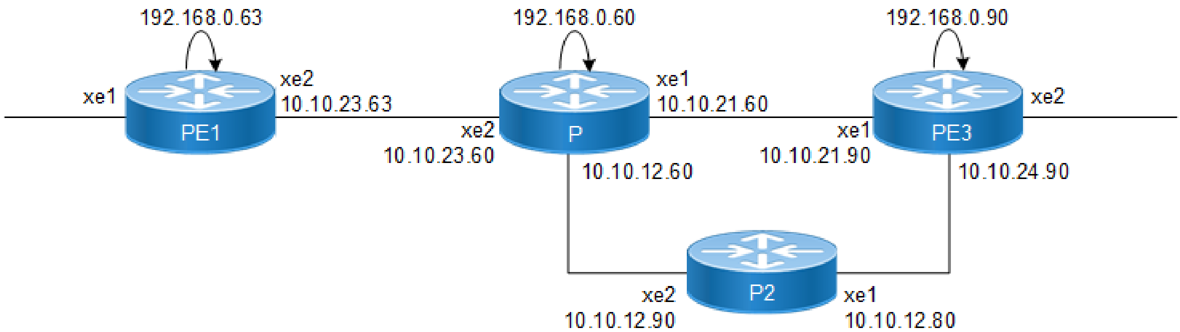

Figure 1-15: Topology for Explicitly Defined Path

PE1 - RSVP-Path

`#configure terminal`	Enter configure mode.
`(config)#rsvp-path P1`	Create an RSVP Path `P1` and enter the `Path` mode.
`(config-path)#10.10.23.60 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#10.10.21.90 loose`	Configure this explicit route path as a `loose` hop.
`(config-path)#exit`	Exit `Path` mode.
`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk T1`	Create an RSVP trunk `T1` and enter the Trunk mode.
`(config-trunk)#no primary cspf`	Since CSPF is enabled by default, specify `no primary cspf` if CSPF is not required.
`(config-trunk)#primary path P1`	Configure trunk `T1` to use the defined path.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#commit`	Commit the transaction.

Validation

```
PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From             Type    LSPName                       State Uptime    Rt
Style  Labelin  Labelout  DSType
192.168.0.90    192.168.0.63     PRI     T1-Primary                        UP     00:00:16
1 1 SE      -          24320     DEFAULT
Total 1 displayed, Up 1, Down 0.

PE2#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
```

```
ondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Egress RSVP:
To        From       Type  LSPName          State Uptime  Rt Style Labelin Labelout DSType
192.168.0.90  192.168.0.63  PRI  T1-Primary        UP  00:00:33 1 1  SE  25600  -
ELSP_CON
Total 1 displayed, Up 1, Down 0. PE1#show ip ospf neighbor
Total number of full neighbors: 1 OSPF process 100 VRF(default):
Neighbor ID  Pri  State      Dead Time  Address    Interface      Instance ID
192.168.0.60   1  Full/Backup   00:00:30  10.10.23.60  xe2        0

P1#show ip ospf neighbor

Total number of full neighbors: 2 OSPF process 100 VRF(default):
Neighbor ID  Pri  State      Dead Time  Address    Interface      Instance ID
192.168.0.90   1  Full/Backup   00:00:35  10.10.21.90  xe8        0
192.168.0.63   1  Full/DR    00:00:36  10.10.23.63  xe2        0

PE2#show ip ospf neighbor

Total number of full neighbors: 1 OSPF process 100 VRF(default):
Neighbor ID  Pri  State      Dead Time  Address    Interface      Instance ID
192.168.0.60   1  Full/DR    00:00:32  10.10.21.60  xe8        0
```

Add a Secondary LSP to the Trunk

Although the attributes of a Secondary LSP are independent of the Primary LSP, a Secondary LSP cannot be configured without first configuring a Primary LSP. In addition to information on how to configure a secondary LSP, this example illustrates how to define a non-default setup and the hold priority for an LSP. Setup and hold priorities are used to determine which LSP should be given a preference when competing for resources. Specifically, the setup priority of an un-established LSP is compared to the hold priorities of established LSPs, and the numerically lower one is given a preference. However, once the LSP is established, its setup priority is never used until it is pre-empted or reset and is being brought up again.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in Enable Label Switching - Minimal Configuration.

Note: If user provides the RSVP path option for secondary, the primary path exclusion logic gets disabled. User needs to keep primary and secondary path mutually exclusive. Else, RSVP-Primary LSP and RSVP-Secondary LSP may select the same next hop, when RSVP is configured with "loose". Hence RSVP-Path first next-hop should be "strict".

PE1 - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#rsvp-path myPath`	Specify an RSVP path to be used.
`(config-path)#10.10.23.60 strict`	Configure this explicit route path as a `strict` hop.
`(config-path)#exit`	Exit Path mode.
`(config)#rsvp-path myPath2`	Specify an RSVP path to be used.

`(config-path)#10.10.23.60 loose`	Configure this explicit route path as a `loose` hop.
`(config-path)#exit`	Exit Path mode.
`(config)#rsvp-trunk T1`	Create an RSVP trunk `T1` and enter the Trunk mode.
`(config-trunk)#no primary cspf`	Since CSPF is enabled by default, specify `no secondary cspf` if CSPF is not required.
`(config-trunk)#primary path myPath`	Specify an RSVP path to be used.
`(config-trunk)#no secondary cspf`	Specify the `no secondary cspf` option for the Secondary LSP.
`(config-trunk)#secondary path myPath2`	Specify an RSVP path to be used.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#commit`	Commit the transaction.

Validation

This example shows the number of configured RSVP sessions in a router.

PE1

```
#show rsvp session count
Total configured: 1, Up 1, Down 0

Total ingress sessions: 1, Up 1, Down 0
Total transit sessions: 0, Up 0, Down 0
Total egress sessions: 0, Up 0, Down 0
```

PE2

```
#show rsvp session count
Total configured: 1, Up 1, Down 0

Total ingress sessions: 0, Up 0, Down 0
Total transit sessions: 0, Up 0, Down 0
Total egress sessions: 1, Up 1, Down 0
```

Add Multiple Secondary LSP to the trunk

RSVP Multiple Secondary feature tries to provide continuous protection when multiple failures happen. In majority scenarios, feature tries to provide seamless protection. This is a proprietary feature where user can configure multiple secondary sessions in a rsvp-trunk. Each secondary will be associated with a priority. Priority secondary sessions must be programmed with a predefined path. User can configure a maximum of five priority levels. Lowest priority number corresponds to highest priority. Highest priority session will be signaled to be programmed as secondary session. If highest priority session cannot come up, then next available secondary will be selected based on polling. During primary session fail-over, programmed secondary priority session will protect the primary and then goes for an MBB update to act as the primary session until primary comes up. Once the highest priority session comes up as acting primary session, next available secondary priority session will be programmed to signal and come up secondary. Re-optimization timer executed once in every 5 minutes to ensure the best priority session serves as secondary. Configuration updates on secondary priority configurations doesn't trigger MBB and session will be restarted. This example illustrates how to create SVI, enable IGP protocols and RSVP on SVI.

Note: Ensure that the VLAN is configured before creating SVI.

Topology

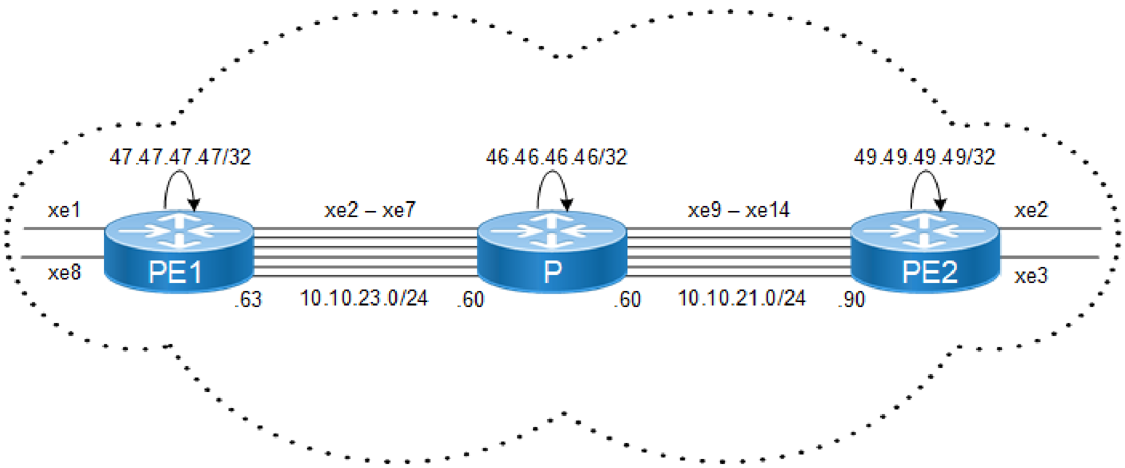

Figure 1-16: Topology for Multiple Secondary Protection

Bridge Configuration

```
bridge 1 protocol ieee vlan-bridge
no bridge 1 spanning-tree enable bridge-forward
```

VLAN creation

```
vlan database
vlan 2-7  bridge 1 state enable
 vlan 501-506 bridge 1 state enable
```

PE1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode
`(config-if)#ip address 47.47.47.47/32 secondary`	Set the secondary IP address for the lo interface
`(config-if)#exit`	Exit interface mode.
`(config)#router rsvp`	Enable RSVP globally.
`(config-router)#exit`	Exit RSVP mode.
`(config)#interface vlan1.2`	Enter the interface mode.
`(config-if)#ip address 10.10.23.1/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.3`	Enter the interface mode.
`(config-if)#ip address 10.10.24.1/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.

(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.4	Enter the interface mode.
(config-if)#ip address 10.10.25.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.5	Enter the interface mode.
(config-if)#ip address 10.10.26.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.6	Enter the interface mode.
(config-if)#ip address 10.10.27.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.7	Enter the interface mode.
(config-if)#ip address 10.10.28.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface xe2	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 2,501	Configure allowed VLANs
(config-if)#switchport trunk native vlan 501	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.

`(config)#interface xe3`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport
`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk
`(config-if)#switchport trunk allowed vlan add 3,502`	Configure allowed VLANs
`(config-if)#switchport trunk native vlan 502`	Configure native VLAN.
`(config-if)#load-interval 30`	Set load interval
`(config-if)#mtu 9192`	Configure the MTU Size.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface xe4`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport
`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk
`(config-if)#switchport trunk allowed vlan add 4,503`	Configure allowed VLANs
`(config-if)#switchport trunk native vlan 503`	Configure native VLAN.
`(config-if)#load-interval 30`	Set load interval
`(config-if)#mtu 9192`	Configure the MTU Size.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface xe5`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport
`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk
`(config-if)#switchport trunk allowed vlan add 5,504`	Configure allowed VLANs
`(config-if)#switchport trunk native vlan 504`	Configure native VLAN.
`(config-if)#load-interval 30`	Set load interval
`(config-if)#mtu 9192`	Configure the MTU Size.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface xe6`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport
`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk
`(config-if)#switchport trunk allowed vlan add 6,505`	Configure allowed VLANs
`(config-if)#switchport trunk native vlan 505`	Configure native VLAN.
`(config-if)#load-interval 30`	Set load interval
`(config-if)#mtu 9192`	Configure the MTU Size.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface xe7`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport

`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk
`(config-if)#switchport trunk allowed vlan add 7,506`	Configure allowed VLANs
`(config-if)#switchport trunk native vlan 506`	Configure native VLAN.
`(config-if)#load-interval 30`	Set load interval
`(config-if)#mtu 9192`	Configure the MTU Size.
`(config-if)#exit`	Exit the interface mode.
`(conf)#rsvp-path p1-r1-r3 mpls`	Create RSVP path
`(conf-path)#10.10.23.2 strict`	Configure nexthop
`(conf-path)#10.10.21.2 strict`	Configure nexthop
`(conf)#rsvp-path sp1-r1-r3 mpls`	Create RSVP path
`(conf-path)#10.10.24.2 strict`	Configure nexthop
`(conf-path)#10.10.22.2 strict`	Configure nexthop
`(conf)#rsvp-path sp2-r1-r3 mpls`	Create RSVP path
`(conf-path)#10.10.25.2 strict`	Configure nexthop
`(conf-path)#10.10.29.2 strict`	Configure nexthop
`(conf)#rsvp-path sp3-r1-r3 mpls`	Create RSVP path
`(conf-path)#10.10.26.2 strict`	Configure nexthop
`(conf-path)#10.10.30.2 strict`	Configure nexthop
`(conf)#rsvp-path sp4-r1-r3 mpls`	Create RSVP path
`(conf-path)#10.10.27.2 strict`	Configure nexthop
`(conf-path)#10.10.31.2 strict`	Configure nexthop
`(conf)#rsvp-path sp5-r1-r3 mpls`	Create RSVP path
`(conf-path)#10.10.28.2 strict`	Configure nexthop
`(conf-path)#10.10.32.2 strict`	Configure nexthop
`(conf)#rsvp-trunk 47-49-test ipv4`	Create a RSVP trunk link
`(conf-trunk)#primary path p1-r1-r3`	Configure primary path for trunk link
`(conf-trunk)#secondary-priority 1 path sp1-r1-r3`	Configure secondary link for trunk link
`(conf-trunk)#secondary-priority 2 path sp2-r1-r3`	Configure secondary link for trunk link
`(conf-trunk)#secondary-priority 3 path sp3-r1-r3`	Configure secondary link for trunk link
`(conf-trunk)#secondary-priority 4 path sp4-r1-r3`	Configure secondary link for trunk link
`(conf-trunk)#secondary-priority 5 path sp5-r1-r3`	Configure secondary link for trunk link
`(conf-trunk)#to 49.49.49.49`	Configure remote node for the LSP
`(config-trunk)#commit`	Commit the transaction.

OSPF configurations

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 47.47.47.47	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.23.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.24.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.25.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.26.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.27.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.28.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 47.47.47.47/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router) #commit	Commit the transaction.

Validation

This example shows the number of configured RSVP sessions in a router.

PE1

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Type    LSPName                        State Uptime    Rt
Style   Labelin  Labelout  DSType
49.49.49.49     47.47.47.47     PRI     47-49-test-Primary             UP    00:32:35
1 1 SE     -        24961     DEFAULT
49.49.49.49     47.47.47.47     SEC     47-49-test-Secondary-Priority-1 UP    00:32:35
1 1 SE     -        24962     DEFAULT
Total 2 displayed, Up 2, Down 0.

Egress RSVP:
To              From            Type    LSPName                        State Uptime    Rt
Style   Labelin  Labelout  DSType
```

```
47.47.47.47     49.49.49.49     PRI     49-47-test-Primary             UP    00:32:53
1 1 SE     24964    -          ELSP_CON
47.47.47.47     49.49.49.49     PRI     49-47-test-Secondary-Priority-1 UP    00:32:47
1 1 SE     24962    -          ELSP_CON
Total 2 displayed, Up 2, Down 0.

#show rsvp trunk multi-sec-detail
Ingress (Secondary-Priority1)
49.49.49.49
  From: 47.47.47.47, LSPstate: Up, LSPname: 47-49-test-Secondary-Priority-1
  Ingress FSM state: Operational
  Establishment Time: 0s 253ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 3
  LSP Protection: None
  Label in: -,  Label out:    24962,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47
  Downstream: 47.46.3.2, vlan1.1003
  Path refresh: 30 seconds (RR enabled) (due in 27970 seconds)
  Resv lifetime: 157 seconds (due in 138 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: SP1-47-49 (in use)
  Configured Explicit Route Detail :
   47.46.3.2/32 strict
   46.45.9.2/32 strict
   45.49.24.2/32 strict
  Session Explicit Route Detail :
   47.46.3.2/32 strict
   46.45.9.2/32 strict
   45.49.24.2/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   <self>
   47.46.3.2
   46.45.9.2
   45.49.24.2
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
```

```
  Trunk Type: mpls
Ingress (Secondary-Priority2)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-2
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 3
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2223, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority3)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-3
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority4)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-4
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
```

```
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority5)
49.49.49.49
  From: 47.47.47.47, LSPstate: Dn, LSPname: 47-49-test-Secondary-Priority-5
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2219, Ext-Tunnel Id: 47.47.47.47
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

P Bridge Configuration

```
bridge 1 protocol ieee vlan-bridge
no bridge 1 spanning-tree enable bridge-forward
```

VLAN creation (Peer configuration for PE1)

```
vlan database
vlan 2-7 bridge 1 state enable
vlan 507-512 bridge 1 state enable
```

VLAN creation (Peer configuration for PE2)

```
vlan database
vlan 9-14  bridge 1 state enable
vlan 513-518 bridge 1 state enable
```

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 46.46.46.46/32 secondary	Set the secondary IP address for the lo interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enable RSVP globally.
(config-router)#exit	Exit RSVP mode.
(config)#interface vlan1.2	Enter the interface mode.
(config-if)#ip address 10.10.23.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.

(config)#interface vlan1.3	Enter the interface mode.
(config-if)#ip address 10.10.24.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.4	Enter the interface mode.
(config-if)#ip address 10.10.25.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.5	Enter the interface mode.
(config-if)#ip address 10.10.26.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.6	Enter the interface mode.
(config-if)#ip address 10.10.27.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.7	Enter the interface mode.
(config-if)#ip address 10.10.28.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.
(config-if)#exit	Exit the interface mode.
(config)#interface vlan1.9	Enter the interface mode.
(config-if)#ip address 10.10.21.1/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.
(config-if)#enable-rsvp	Enable RSVP at the interface level.

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`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.10`	Enter the interface mode.
`(config-if)#ip address 10.10.22.1/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.11`	Enter the interface mode.
`(config-if)#ip address 10.10.29.1/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.12`	Enter the interface mode.
`(config-if)#ip address 10.10.30.1/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.13`	Enter the interface mode.
`(config-if)#ip address 10.10.31.1/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.14`	Enter the interface mode.
`(config-if)#ip address 10.10.32.1/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface xe2`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport
`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk

(config-if)#switchport trunk allowed vlan add 2,507	Configure allowed VLANs
(config-if)#switchport trunk native vlan 507	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe3	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 3,508	Configure allowed VLANs
(config-if)#switchport trunk native vlan 508	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe4	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 4,509	Configure allowed VLANs
(config-if)#switchport trunk native vlan 509	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe5	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 5,510	Configure allowed VLANs
(config-if)#switchport trunk native vlan 510	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe6	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 6,511	Configure allowed VLANs

(config-if)#switchport trunk native vlan 511	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe7	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 7,512	Configure allowed VLANs
(config-if)#switchport trunk native vlan 512	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe9	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 9,513	Configure allowed VLANs
(config-if)#switchport trunk native vlan 513	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe10	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 10,514	Configure allowed VLANs
(config-if)#switchport trunk native vlan 514	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe11	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 11,515	Configure allowed VLANs
(config-if)#switchport trunk native vlan 515	Configure native VLAN.
(config-if)#load-interval 30	Set load interval

(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe12	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 12,516	Configure allowed VLANs
(config-if)#switchport trunk native vlan 516	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe13	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 13,517	Configure allowed VLANs
(config-if)#switchport trunk native vlan 517	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe14	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 14,518	Configure allowed VLANs
(config-if)#switchport trunk native vlan 518	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#commit	Commit the transaction.

OSPF configurations

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 46.46.46.46	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.21.0/24 area 0	Define the network on which OSPF runs and associate the area ID

(config-router)#network 10.10.22.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.23.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.24.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.25.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.26.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.27.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.28.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.29.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.30.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.31.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.32.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 46.46.46.46/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router) #commit	Commit the transaction.

PE2 Bridge Configuration

```
bridge 1 protocol ieee vlan-bridge
no bridge 1 spanning-tree enable bridge-forward
```

PE2 VLAN Creation

```
vlan database
vlan 9-14  bridge 1 state enable
vlan 519-524 bridge 1 state enable
```

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip address 49.49.49.49/32 secondary	Set the secondary IP address for the lo interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enable RSVP globally.
(config-router)#exit	Exit RSVP mode.
(config)#interface vlan1.9	Enter the interface mode.
(config-if)#ip address 10.10.21.2/24	Configure the IP Address
(config-if)#mtu 1600	Configure MTU size.
(config-if)#label-switching	Enable MPLS.
(config-if)#ip ospf network point-to-point	Enable OSPF point-to-point network type.

`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.10`	Enter the interface mode.
`(config-if)#ip address 10.10.22.2/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.11`	Enter the interface mode.
`(config-if)#ip address 10.10.29.2/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.12`	Enter the interface mode.
`(config-if)#ip address 10.10.30.2/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.13`	Enter the interface mode.
`(config-if)#ip address 10.10.31.2/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface vlan1.14`	Enter the interface mode.
`(config-if)#ip address 10.10.32.2/24`	Configure the IP Address
`(config-if)#mtu 1600`	Configure MTU size.
`(config-if)#label-switching`	Enable MPLS.
`(config-if)#ip ospf network point-to-point`	Enable OSPF point-to-point network type.
`(config-if)#enable-rsvp`	Enable RSVP at the interface level.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface xe9`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport
`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk

(config-if)#switchport trunk allowed vlan add 9,519	Configure allowed VLANs
(config-if)#switchport trunk native vlan 519	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe10	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 10,520	Configure allowed VLANs
(config-if)#switchport trunk native vlan 520	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe11	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 11,521	Configure allowed VLANs
(config-if)#switchport trunk native vlan 521	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe12	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 12,522	Configure allowed VLANs
(config-if)#switchport trunk native vlan 522	Configure native VLAN.
(config-if)#load-interval 30	Set load interval
(config-if)#mtu 9192	Configure the MTU Size.
(config-if)#exit	Exit the interface mode.
(config)#interface xe13	Enter the interface mode.
(config-if)#switchport	Configure Switchport
(config-if)#bridge-group 1	Assign a Bridge ID to the port channel
(config-if)#switchport mode trunk	Configure trunk
(config-if)#switchport trunk allowed vlan add 13,523	Configure allowed VLANs

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`(config-if)#switchport trunk native vlan 523`	Configure native VLAN.
`(config-if)#load-interval 30`	Set load interval
`(config-if)#mtu 9192`	Configure the MTU Size.
`(config-if)#exit`	Exit the interface mode.
`(config)#interface xe14`	Enter the interface mode.
`(config-if)#switchport`	Configure Switchport
`(config-if)#bridge-group 1`	Assign a Bridge ID to the port channel
`(config-if)#switchport mode trunk`	Configure trunk
`(config-if)#switchport trunk allowed vlan add 14,524`	Configure allowed VLANs
`(config-if)#switchport trunk native vlan 524`	Configure native VLAN.
`(config-if)#load-interval 30`	Set load interval
`(config-if)#mtu 9192`	Configure the MTU Size.
`(config-if)#exit`	Exit the interface mode.
`(conf)#rsvp-path sp1-r3-r1 mpls`	Create RSVP path
`(conf-path)#10.10.21.1 strict`	Configure nexthop
`(conf-path)#10.10.23.1 strict`	Configure nexthop
`(conf)#rsvp-path sp2-r3-r1 mpls`	Create RSVP path
`(conf-path)#10.10.22.1 strict`	Configure nexthop
`(conf-path)#10.10.24.1 strict`	Configure nexthop
`(conf)#rsvp-path sp2-r3-r1 mpls`	Create RSVP path
`(conf-path)#10.10.29.2 strict`	Configure nexthop
`(conf-path)#10.10.25.1 strict`	Configure nexthop
`(conf)#rsvp-path sp3-r3-r1 mpls`	Create RSVP path
`(conf-path)#10.10.30.1 strict`	Configure nexthop
`(conf-path)#10.10.26.1 strict`	Configure nexthop
`(conf)#rsvp-path sp4-r3-r1 mpls`	Create RSVP path
`(conf-path)#10.10.31.1 strict`	Configure nexthop
`(conf-path)#10.10.27.1 strict`	Configure nexthop
`(conf)#rsvp-path sp5-r3-r1 mpls`	Create RSVP path
`(conf-path)#10.10.32.1 strict`	Configure nexthop
`(conf-path)#10.10.28.1 strict`	Configure nexthop
`(conf)#rsvp-trunk 49-47-test ipv4`	Create a RSVP trunk link
`(conf-trunk)#primary path p1-r3-r1`	Configure primary path for trunk link
`(conf-trunk)#secondary-priority 1 path sp1-r3-r1`	Configure secondary link for trunk link
`(conf-trunk)#secondary-priority 2 path sp2-r3-r1`	Configure secondary link for trunk link
`(conf-trunk)#secondary-priority 3 path sp3-r3-r1`	Configure secondary link for trunk link
`(conf-trunk)#secondary-priority 4 path sp4-r3-r1`	Configure secondary link for trunk link

(conf-trunk)#secondary-priority 5 path sp5-r3-r1	Configure secondary link for trunk link
(conf-trunk)#to 47.47.47.47	Configure remote node for the LSP
(conf-trunk)#commit	Commit the transaction.

OSPF configurations

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#ospf router-id 49.49.49.49	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.21.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.22.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.29.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.30.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.31.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 10.10.32.0/24 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#network 49.49.49.49/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router) #commit	Commit the transaction.

Validation

This example shows the number of configured RSVP sessions in a router.

PE2

```
 #show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Type    LSPName                       State Uptime    Rt
Style  Labelin  Labelout  DSType
47.47.47.47     49.49.49.49     PRI     49-47-test-Primary               UP    00:34:57
1 1 SE     -         24970     DEFAULT
47.47.47.47     49.49.49.49     SEC     49-47-test-Secondary-Priority-1 UP    00:34:56
1 1 SE     -         24968     DEFAULT
Total 2 displayed, Up 2, Down 0.
```

```
Egress RSVP:
To              From            Type    LSPName                     State Uptime    Rt
Style  Labelin  Labelout  DSType
49.49.49.49     47.47.47.47     PRI     47-49-test-Primary             UP    00:34:45
1 1 SE     31364    -         ELSP_CON
49.49.49.49     47.47.47.47     PRI     47-49-test-Secondary-Priority-1 UP   00:34:44
1 1 SE     31360    -         ELSP_CON
Total 2 displayed, Up 2, Down 0.

#show rsvp trunk multi-sec-detail
Ingress (Secondary-Priority1)
47.47.47.47
  From: 49.49.49.49, LSPstate: Up, LSPname: 49-47-test-Secondary-Priority-1
  Ingress FSM state: Operational
  Establishment Time: 1s 71ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 3
  LSP Protection: None
  Label in: -,  Label out:    24968,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2214, Ext-Tunnel Id: 49.49.49.49
  Downstream: 45.49.24.1, vlan1.1024
  Path refresh: 30 seconds (RR enabled) (due in 27829 seconds)
  Resv lifetime: 157 seconds (due in 145 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: SP1-49-47 (in use)
  Configured Explicit Route Detail :
   45.49.24.1/32 strict
   46.45.9.1/32 strict
   47.46.3.1/32 strict
  Session Explicit Route Detail :
   45.49.24.1/32 strict
   46.45.9.1/32 strict
   47.46.3.1/32 strict
  Record route:
   ------------------------------------------------------------
   IP Address        Label
   ------------------------------------------------------------
   <self>
   45.49.24.1
   46.45.9.1
   47.46.3.1
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
```

```
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority2)
47.47.47.47
  From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-2
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 3
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2215, Ext-Tunnel Id: 49.49.49.49
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority3)
47.47.47.47
  From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-3
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2213, Ext-Tunnel Id: 49.49.49.49
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority4)
47.47.47.47
  From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-4
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
```

```
  Tunnel Id: 5001, LSP Id: 2213, Ext-Tunnel Id: 49.49.49.49
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority5)
47.47.47.47
  From: 49.49.49.49, LSPstate: Dn, LSPname: 49-47-test-Secondary-Priority-5
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2213, Ext-Tunnel Id: 49.49.49.49
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

Add Administrative Group Constraints to an LSP

To add administrative group constraints (also known as color constraints) to an LSP:

- Configure support for required administrative groups in NSM on all participating routers
- Configure required administrative groups on all participating interfaces

The configuration in this example forces the primary LSP to be setup through links that belong either to administrative group A or C. A link that does not belong to either of these administrative groups will not be used for setting up the LSP.

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in Enable Label Switching - Minimal Configuration.

PE1 - NSM

#configure terminal	Enter configure mode.
(config)#admin-group A 0	Add new administrative groups, specify their names and assign bit values to them.
(config)#admin-group B 1	
(config)#admin-group C 2	
(config)#admin-group D 3	
(config)#admin-group E 4	
(config)#interface xe0	Enter interface mode.
(config-if)#admin-group A	Add administrative groups to the links. When used in the interface mode, this command adds a link between an interface and a group. The name is the name of the group previously configured. You can have multiple groups per interface.
(config-if)#admin-group B	
(config-if)#admin-group C	

`(config-if)#exit`	Exit interface mode.
`(config)#interface xe2`	Enter interface mode.
`(config-if)#admin-group E`	Add administrative groups to the links. When used in the interface mode, this command adds a link between an interface and a group. The name is the name of the group previously configured. You can have multiple groups per interface.
`(config-if)#admin-group D`	
`(config-if)#commit`	Commit the transaction.

P - NSM

`#configure terminal`	Enter configure mode.
`(config)#admin-group A 0`	Add new administrative groups and specify their names and assign bit values to them.
`(config)#admin-group C 2`	
`(config)#interface xe2`	Enter interface mode
`(config-if)#admin-group A`	Add administrative groups to the links. When used in the interface mode, this command adds a link between an interface and a group. The name is the name of the group previously configured. You can have multiple groups per interface.
`(config-if)#admin-group C`	
`(config-if)#commit`	Commit the transaction.

PE1 - RSVP-TE

`(config)#router rsvp`	Enter the router mode for RSVP.
`(config-router)#rsvp-path P1`	Configure RSVP path.
`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk T1`	Create an RSVP trunk `T1` and enter the Trunk mode.
`(config-trunk)#no primary cspf`	Since CSPF is enabled by default, specify n`o primary cspf` if CSPF is not required.
`(config-trunk)#primary path P1`	Specify an RSVP primary path to be used.
`(config-trunk)#no primary cspf`	Specify the `no primary cspf` option for the LSP.
`(config-trunk)#primary include-any A`	Set up the LSP with admin group constraint A.
`(config-trunk)#primary include-any C`	Set up the LSP with admin group constraint C.
`(config-trunk)#to 192.168.0.90`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#commit`	Commit the transaction.

Configure Global Parameters

Some common parameters can be configured in the Router mode on the RSVP-TE daemon. These parameters are global and affect all LSPs. In the following example the interval between two consecutive hello messages is set. The neighbor is defined by the neighbor command. Hello exchanges are enabled only between explicitly configured neighbors (configure this router as a neighbor on P (IP address `10.10.23.60`).

Note: This example is based on the assumption that a minimal configuration exists on all participating routers as described in Enable Label Switching - Minimal Configuration.

PE1 - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#router rsvp`	Enter the router mode for RSVP.
`(config-router)#hello-interval 10`	Set the `hello-interval` (in seconds) between hello packets.
`(config-router)#hello-timeout 35`	Set the `hello-timeout value`. If an LSR has not received a Hello message from a peer within this period, all sessions shared with this peer are reset.
`(config-router)#neighbor 10.10.23.60`	Explicitly specify the neighbor to exchange Hello messages with.
`(config-router)#commit`	Commit the transaction.

P - RSVP-TE

`#configure terminal`	Enter configure mode.
`(config)#router rsvp`	Enter the router mode for RSVP.
`(config-router)#hello-interval 10`	Set the `hello-interval` (in seconds) between hello packets.
`(config-router)#hello-timeout 35`	Set the `hello-timeout value`. If an LSR has not received a Hello message from a peer within this period, all sessions shared with this peer are reset.
`(config-router)#neighbor 10.10.23.63`	Explicitly specify the neighbor to exchange Hello messages with.
`(config-router)#commit`	Commit the transaction.

Fast Reroute Configuration (one-to-one method)

The Fast Reroute (FRR) configuration is a MPLS resiliency technology that provides fast traffic recovery when there is a link or router failure on mission critical services. These mechanisms enable the re-direction of traffic onto backup LSP tunnels in tens of milliseconds, in the event of a failure. The one-to-one backup method creates detour LSPs for each protected LSP at each potential point of local repair. This method is used to protect links and nodes during network failure.

In the below configurations each FRR trunk is mapped to VPWS,VPLS, and L3 VPN services.So it includes configurations of VPWS,VPLS and L3 VPN also.

Figure 1-17 is a simple topology example for FRR:

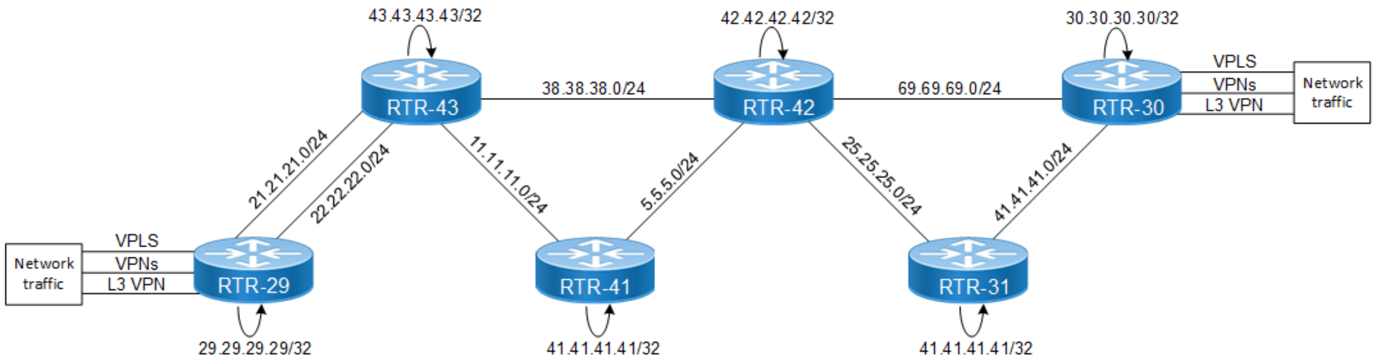

Figure 1-17: Topology Example for Fast Reroute

RTR-29

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 29.29.29.29/32 secondary`	Set a secondary IP address of the interface
`(config-if)#no shutdown`	Administratively bring the interface up.
`(config-if)#exit`	Exit interface mode.
`(config)#router-id 29.29.29.29`	Configure the router ID.
`(config)#router rsvp`	Enter to router rsvp mode.
`(config-router)#exit`	Exit the router mode
`(config)#router ldp`	Enter to router LDP mode.
`(config-router)#targeted-peer ipv4 30.30.30.30`	Configure targeted peer.
`(config-router-targeted-peer)#exit-targeted-peer-mode`	Exit-targeted-peer-mode
`(config-router)#exit`	Exit router mode
`(config)#interface xe21`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface.
`(config-if)#ip address 21.21.21.29/24`	Set an IP address of the interface.
`(config-if)#no shutdown`	Administratively no shutdown the interface.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#enable-ldp ipv4`	Enable LDP on this interface
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe22`	Enter interface mode.
`(config-if)#label-switching`	Enable label switching on interface
`(config-if)#enable-ldp ipv4`	Enable LDP on this interface
`(config-if)#ip address 22.22.22.29/24`	Set an IP address of the interface.
`(config-if)#no shutdown`	Administratively no shutdown the interface.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router ospf`	Enter the router configure mode for OSPF.

`(config-router)#router-id 29.29.29.29`	Configure OSPF router-ID same as loopback interface IP address

`(config-router)#network 21.21.21.0/24 area 0`
`(config-router)#network 22.22.22.0/24 area 0`
`(config-router)#network 29.29.29.29/32 area 0`
	Define the network on which OSPF runs and associate the area ID

`(config-router)#exit`	Exit the router configure mode.
`(config)#rsvp-path p21`	Enter the path mode for RSVP pt1.
`(config-path)#21.21.21.43 strict`	Configure this explicit route path as a strict hop.
`(config-path)#38.38.38.42 strict`	Configure this explicit route path as a strict hop.
`(config-path)#69.69.69.30 strict`	Configure this explicit route path as a strict hop.
`(config)#exit`	Exit the path mode.
`(config)#rsvp-trunk to_30 ipv4`	Enter the trunk mode for RSVP.
`(config-trunk)#primary fast-reroute protection one-to-one`	Configure primary fast-reroute protection facility for a trunk.
`(config-trunk)#primary fast-reroute node-protection`	Configure primary fast-reroute node protection for the trunk
`(config-trunk)#primary path p21`	Configure trunk to 30 to use the defined path.
`(config-trunk)#to 30.30.30.30`	Specify the IPv4 egress (destination point) for the LSP.
`(config-trunk)#exit`	Exit from trunk mode.
`(config)#ip vrf vrf1`	Configure VRF instance
`(config-vrf)#rd 100:1`	Configure Router Distinguisher value
`(config-vrf)#route-target both 100:1`	Configure route-target as both
`(config-vrf)#exit`	Exit the path mode.
`(config)#interface xe43`	Enter to the interface mode
`(config-if)#ip vrf forwarding vrf1`	Bind the VRF instance to the interface
`(config-if)#ip address 43.43.43.29/24`	Configure IP address
`(config-if)#exit`	Exit interface mode.
`(config)#router bgp 100`	Configure BGP router instance
`(config-router)#neighbor 30.30.30.30 remote-as 100`	Configure neighbor with remote-as
`(config-router)#neighbor 30.30.30.30 update-source 29.29.29.29`	Configure update source as loopback address
`(config-router)#address-family vpnv4 unicast`	Configure VPNv4 address family
`(config-router-af)#neighbor 30.30.30.30 activate`	Activate the VPN neighbor
`(config-router-af)#exit-address-family`	Exit the VPN address family
`(config-router)#address-family ipv4 vrf vrf1`	Configure VRF address family
`(config-router-af)redistribute connected`	Redistribute connected route
`(config-router-af)exit-address-family`	Exit VRF address family
`(config-router)#exit`	Exit router mode
`(config)#mpls l2-circuit vlan10 10 30.30.30.30`	Configure Virtual circuit.
`(config-pseudowire)#exit`	Exit pseudowire config mode.
`(config)#service-template st1`	Template configuration

(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template st2	Template configuration
(config-svc)#match outer-vlan 30	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe44	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-l2-circuit t1 service-template st1	Bind the interface to the VC with service template
(config-if)#exit	Exit interface configuration mode
(config)#mpls vpls vpls30 30	Configure VPLS instance
(config-vpls)#signaling ldp	Configure VPLS signaling as LDP
(config-vpls-sig)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 30.30.30.30	Configure VPLS peer
(config-vpls-sig)#exit-signaling	Exit VPLS configuration mode
(config)#interface xe45	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-vpls vpls30 service-template st2	Bind the VPLS instance to the interface
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

RTR-43

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 43.43.43.43/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 43.43.43.43	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xe5/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 11.11.11.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe9/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface

(config-if)#ip address 21.21.21.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe9/2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 22.22.22.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe13/2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 38.38.38.43/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 43.43.43.43	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 11.11.11.0/24 area 0 (config-router)#network 22.22.22.0/24 area 0 (config-router)#network 21.21.21.0/24 area 0 (config-router)#network 38.38.38.0/24 area 0 (config-router)#network 43.43.43.43/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction.

RTR-42

(config)#interface lo	Enter interface mode.
(config-if)#ip address 42.42.42.42/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 42.42.42.42	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 5.5.5.42/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe10/1	Enter interface mode.

(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 25.25.25.42/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe3	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 38.38.38.42/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe4	Enter interface mode
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 69.69.69.42/24	Specify an IP address for the interface
(config-if)#no shutdown	Administratively no shutdown the interface
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface
(config-if)#exit	Exit interface mode
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 42.42.42.42	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 5.5.5.0/24 area 0 (config-router)#network 25.25.25.0/24 area 0 (config-router)#network 69.69.69.0/24 area 0 (config-router)#network 38.38.38.0/24 area 0 (config-router)#network 42.42.42.42/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction

RTR-41

(config)#interface lo	Enter interface mode.
(config-if)#ip address 44.44.44.44/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 44.44.44.44	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xe1/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 1.1.1.41/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.

(config)#interface xe2	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 5.5.5.41/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe5/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 11.11.11.41/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 44.44.44.44	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 5.5.5.0/24 area 0 (config-router)#network 1.1.1.0/24 area 0 (config-router)#network 11.11.11.0/24 area 0 (config-router)#network 44.44.44.44/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction.

RTR-31

(config)#interface lo	Enter interface mode.
(config-if)#ip address 31.31.31.31/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 31.31.31.31	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#interface xe1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 1.1.1.31/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe25	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#ip address 25.25.25.31/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe41	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 41.41.41.31/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 31.31.31.31	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 1.1.1.0/24 area 0 (config-router)#network 25.25.25.0/24 area 0 (config-router)#network 41.41.41.0/24 area 0 (config-router)#network 31.31.31.31/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction.

RTR-30

(config)#interface lo	Enter interface mode.
(config-if)#ip address 30.30.30.30/32 secondary	Set a secondary IP address of the interface
(config-if)#no shutdown	Administratively shutdown the interface.
(config-if)#exit	Exit interface mode.
(config)#router-id 30.30.30.30	Configure the router ID.
(config)#router rsvp	Enter to router RSVP mode.
(config-router)#exit	Exit the router mode
(config)#router ldp	Enter to router LDP mode.
(config-router)#targeted-peer ipv4 29.29.29.29	Configure targeted peer.
(config-router-targeted-peer)#exit-targeted-peer-mode	Exit-targeted-peer-mode
(config-router)#exit	Exit router mode
(config)#interface xe41	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#ip address 41.41.41.30/24	Set an IP address of the interface.
(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#enable-ldp ipv4	Enable LDP on this interface
(config-if)#exit	Exit interface mode.
(config)#interface xe54/1	Enter interface mode.
(config-if)#label-switching	Enable label switching on interface
(config-if)#enable-ldp ipv4	Enable LDP on this interface
(config-if)#ip address 69.69.69.30/24	Set an IP address of the interface.

(config-if)#no shutdown	Administratively no shutdown the interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf	Enter the router configure mode for OSPF.
(config-router)#router-id 30.30.30.30	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 41.41.41.0/24 area 0 (config-router)#network 69.69.69.0/24 area 0 (config-router)#network 30.30.30.30/32 area 0	Define the network on which OSPF runs and associate the area ID
(config-router)#commit	Commit the transaction.
(config)#rsvp-path p41	Enter the path mode for RSVP pt1.
(config-path)#41.41.41.31 strict	Configure this explicit route path as a strict hop.
(config-path)#1.1.1.41 strict	Configure this explicit route path as a strict hop.
(config-path)#11.11.11.43 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-trunk to_29 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#primary fast-reroute protection one-to-one	Configure primary fast-reroute protection facility for a trunk.
(config-trunk)#primary fast-reroute node-protection	Configure primary fast-reroute node protection for the trunk
(config-trunk)#primary path p41	Configure trunk to_29 to use the defined path.
(config-trunk)#to 29.29.29.29	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit from trunk mode.
(config)#ip vrf vrf1	Configure VRF instance
(config-vrf)#rd 100:1	Configure Router Distinguisher value
(config-vrf)#route-target both 100:1	Configure route-target as both
(config-vrf)#exit	Exit the path mode.
(config)#interface xe23	Enter to the interface mode
(config-if)#ip vrf forwarding vrf1	Bind the VRF instance to the interface
(config-if)#ip address 23.23.23.29/24	Configure IP address
(config-if)#exit	Exit interface mode.
(config)#router bgp 100	Configure BGP router instance
(config-router)#neighbor 29.29.29.29 remote-as 100	Configure neighbor with remote-as
(config-router)#neighbor 29.29.29.29 update-source 30.30.30.30	Configure update source as loopback address
(config-router)#address-family vpnv4 unicast	Configure VPNv4 address family
(config-router-af)#neighbor 29.29.29.29 activate	Activate the VPN neighbor
(config-router-af)#exit-address-family	Exit the VPN address family
(config-router)#address-family ipv4 vrf vrf1	Configure VRF address family
(config-router-af)redistribute connected	Redistribute connected route
(config-router-af)exit-address-family	Exit VRF address family

(config-router)#exit	Exit router mode
(config)#mpls l2-circuit vlan10 10 29.29.29.29	Configure Virtual circuit.
(config-pseudowire)#exit	Exit pseudowire config mode.
(config)#service-template st1	Template configuration
(config-svc)#match outer-vlan 10	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#service-template st2	Template configuration
(config-svc)#match outer-vlan 30	Match criteria under template configuration
(config-svc)#exit	Exit service template mode
(config)#interface xe24	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-l2-circuit vlan10 service-template st1	Bind the interface to the VC with service template
(config-if)#exit	Exit interface configuration mode
(config)#mpls vpls vpls30 30	Configure VPLS instance
(config-vpls)#signaling ldp	Configure VPLS signaling as LDP
(config-vpls-sig)#vpls-type vlan	Configure VPLS type as VLAN encapsulation
(config-vpls-sig)#vpls-peer 29.29.29.29	Configure VPLS peer
(config-vpls-sig)#exit-signaling	Exit VPLS configuration mode
(config)#interface xe25	Enter interface configuration mode
(config-if)#switchport	Configure interface as switch port
(config-if)#mpls-vpls vpls30 service-template st2	Bind the VPLS instance to the interface
(config-if-vpls)#split-horizon group access1	Configure split-horizon group on VPLS
(config-if-vpls)#exit	Exit VPLS attachment-circuit mode
(config-if)#commit	Commit the transaction.

Validation

```
RTR-30#show rsvp session
Ingress RSVP:
To              From            State                Pri Rt  Style Labelin
Labelout LSPName                          Uptime  Est.time   D
SType
29.29.29.29     30.30.30.30     Up                   Yes 1 1 SE    -
24322    to_29-Primary                    00:07:53 0s 118ms  D
EFAULT
29.29.29.29     69.69.69.30     Up                   No  1 1 SE    -
24322    to_29-Detour                     00:07:53 0s 4ms   DEF
AULT
Total 2 displayed, Up 2, Down 0.

Egress RSVP:
To              From            State                Pri Rt  Style Labelin
Labelout LSPName                          Uptime  Est.time   D
SType
```

```
30.30.30.30    29.29.29.29    Up                 Yes 1 1 SE    24960   -
to_30-Primary                   00:07:57 N/A    ELSP
_CON
30.30.30.30    25.25.25.42    Up                 Yes 1 1 SE    24961   -
to_30-Detour                    00:07:57 N/A    ELSP
_CON
Total 2 displayed, Up 2, Down 0.


RTR-30#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf       Nexthop
R(t)>   29.29.29.29/32     1       5001       Yes   LSP_DEFAULT    24322
xe2          41.41.41.31
R(t)>   29.29.29.29/32     2       5001       No    LSP_DEFAULT    24322
xe1          69.69.69.42
RTR-30#

RTR-30#show mpls vrf-table
Output for IPv4 VRF table with id: 2
 Primary FTN entry with FEC: 43.43.43.0/24, id: 1, row status: Active
  Owner: BGP, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
  Tunnel id: 5001,   Protected LSP id: 0, QoS Resource id: 0, Description: N/A
    Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
     Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 6
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 6, owner: BGP, out intf: xe1, out label: 25602
    Nexthop addr: 29.29.29.29       cross connect ix: 7, op code: Push and
Lookup


Link 41.41.41.0/24 Goes down. Interface xe41 on router 30 is admistratively
disabled with the "shutdown command".

RTR-30#

RTR-30#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
RTR-30(config)#int xe41
RTR-30(config-if)#shutdown
RTR-30(config-if)#


RTR-30#show rsvp session
Ingress RSVP:
To               From            State                 Pri Rt  Style Labelin
Labelout LSPName                           Uptime  Est.time   D
SType
29.29.29.29    30.30.30.30    Using Backup       Yes 0 0 SE    -       -
to_29-Primary                 N/A    DEFAULT
29.29.29.29    30.30.30.30    Dn                 Yes 0 0 SE    -       -
to_29-Primary                 N/A    DEFAULT
```

```
29.29.29.29     69.69.69.30     Up                    No  1 1 SE    -
24322    to_29-Detour                   00:10:53 0s 4ms  DEF
AULT
Total 3 displayed, Up 1, Down 2.

Egress RSVP:
To              From            State                 Pri Rt  Style Labelin
Labelout LSPName                        Uptime  Est.time   D
SType
30.30.30.30    29.29.29.29    Up                  Yes 1 1 SE    24960   -
to_30-Primary                   00:10:57 N/A    ELSP
_CON
Total 1 displayed, Up 1, Down 0.


RTR-30#show mpls vc-table
VC-ID       Vlan-ID  Inner-Vlan-ID  Access-Intf   Network-Intf  Out Label
Tunnel-Label  Nexthop         Status
10         N/A     N/A           xe4         xe1         24321     24322
29.29.29.29     Active
RTR-30#


RTR-30#show mpls vpls mesh
VPLS-ID    Peer Addr        Tunnel-Label  In-Label   Network-Intf   Out-Label
Lkps/St   PW-INDEX  SIG-Protocol  Status
30         29.29.29.29      24322         24320      xe41           24320
2/Up      2         LDP           Active
```

Link 41.41.41.0/24 is reestablished. Interfce xe41 is administrativly re-enabled.

```
RTR-30#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
RTR-30(config)#int xe41
RTR-30(config-if)#no shutdown
RTR-30(config-if)#
RTR-30#


RTR-30#show rsvp session
Ingress RSVP:
To              From            State                 Pri Rt  Style Labelin
Labelout LSPName                        Uptime  Est.time   D
SType
29.29.29.29     30.30.30.30     Up                    Yes 1 1 SE    -
24322    to_29-Primary                  00:00:01 0s 8ms  DEF
AULT
29.29.29.29     69.69.69.30     Up                    No  1 1 SE    -
24322    to_29-Detour                   00:00:01 0s 8ms  DEF
AULT
Total 2 displayed, Up 2, Down 0.

Egress RSVP:
To              From            State                 Pri Rt  Style Labelin
Labelout LSPName                        Uptime  Est.time   D
```

```
SType
30.30.30.30    29.29.29.29    Up                    Yes 1 1 SE    24960   -
to_30-Primary                   00:13:22 N/A    ELSP
_CON
30.30.30.30    25.25.25.42    Up                    Yes 1 1 SE    24961   -
to_30-Detour                    00:00:08 N/A    ELSP
_CON
Total 2 displayed, Up 2, Down 0.


RTR-30#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC                 FTN-ID    Tunnel-id   Pri   LSP-Type        Out-
Label    Out-Intf        Nexthop
R(t)>   29.29.29.29/32     1       5001       Yes   LSP_DEFAULT    24322
xe41           41.41.41.31
R(t)>   29.29.29.29/32     2       5001       No    LSP_DEFAULT    24322
xe54/1           69.69.69.42
```

Note: The primary LSP, which is in using backup state shall continue to use backup path in case where secondary is provisioned after the LSP state is changed to switch to backup.

MPLS RSVP PING and TRACEROUTE

This example shows MPLS ping and trace route for RSVP

```
#ping mpls rsvp tunnel-name to_30 detail
Sending 5 MPLS Echos to  to_30 , timeout is 5 seconds
Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed
Type 'Ctrl+C' to abort
! seq_num = 1 30.30.30.30 0.28 ms
! seq_num = 2 30.30.30.30 0.24 ms
! seq_num = 3 30.30.30.30 0.22 ms
! seq_num = 4 30.30.30.30 0.22 ms
! seq_num = 5 30.30.30.30 0.22 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.22/0.25/0.28


RTR-29#trace mpls rsvp tunnel-name to_30 detail
Tracing MPLS Label Switched Path to  to_30 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
```

```
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

  0 21.21.21.29 [Labels:  24320]
R 1 43.43.43.43 [Labels:  24320] 123.22 ms
R 2 42.42.42.42 [Labels:  24960] 1.60 ms
! 3 30.30.30.30 1.62 ms
```

MPLS RSVP Entropy Label Capabilities

To share the load across multiple members of a LAG port in the core of an MPLS network we can use entropy labels

An Entropy Label is always preceded by an Entropy level indicator which is a special Label with value seven, and indicates the next label present is an Entropy label. The trade off is the MPLS stack depth increases by two and it reduces overhead on transit routers.

Note: Load balancing is enabled by default for all the parameters. If you enable load balancing manually, then all the parameters enabled by default are reset and you need to enable the parameters based on which traffic should be load balanced.

Entropy labels will only be added when the remote edge node advertises its capability for Entropy.

The examples below show how entropy can be enabled on a provider edge node as per the setup we need to enable on RTR29 and RTR30 to have entropy enabled in both directions:

```
(config)#router rsvp
(config-router)#entropy-label-capability
```

This enables ELC signaling for RSVP.

For validation, use:

```
#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN, K - CLI FTN, t - 
tunnel
L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code    FEC          FTN-ID Tunnel-id  Pri  LSP-Type   Out- Label  ELC  Out-Intf  Nexthop
R(t)> 2 9.29.29.29/32  1    5001      Yes LSP_DEFAULT   24322    yes
xe2    1.41.41.31
R(t)>   29.29.29.29/32  2   5001       No  LSP_DEFAULT   4322    yes
xe1    69.69.69.42


#show rsvp session ingress detail
Ingress (Primary)
41.41.41.31
From: 29.29.29.29, LSPstate: Up, LSPname: t1-Primary
```

```
Ingress FSM state: Operational
Establishment Time: 0s 3ms
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
IGP-Shortcut: Disabled, LSP metric: 1
LSP Protection: None
Label in: -, Label out: 24320, ELC
```

MPLS RSVP LSP Re-optimization

Follow these steps to configure RSVP LSP Re-optimization.

`#configure terminal`	Enter configure mode.
`(config)#rsvp-trunk T1`	Create an RSVP trunk T1 and enter the Trunk mode.
`(config-trunk)#reoptimize`	Enable re-optimization of the session.

`#configure terminal`	Enter configure mode.
`(config)#router rsvp`	Enter RSVP mode
`(config-router)#lsp-reoptimization-timer 5`	Sets the re-optimization timer for the session.

Follow these steps to force the LSP to be re-optimized.

`#rsvp-trunk t1 force-reoptimize`	Re-optimize the LSP forcefully

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CHAPTER 2 RSVP-TE Facility Backup (Facility Bypass)

RSVP supports multiple path protection mechanisms and facility backup is one of them. With facility backup protection, N number of LSPs sharing the common path can be protected using one bypass tunnel which leads to resource utilization.

Note: Do not configure a facility backup trunk with the same transit node as that of the primary trunk.

Topology

As shown in Figure 2-18, we have four routers R1, R2, R3, and R4.

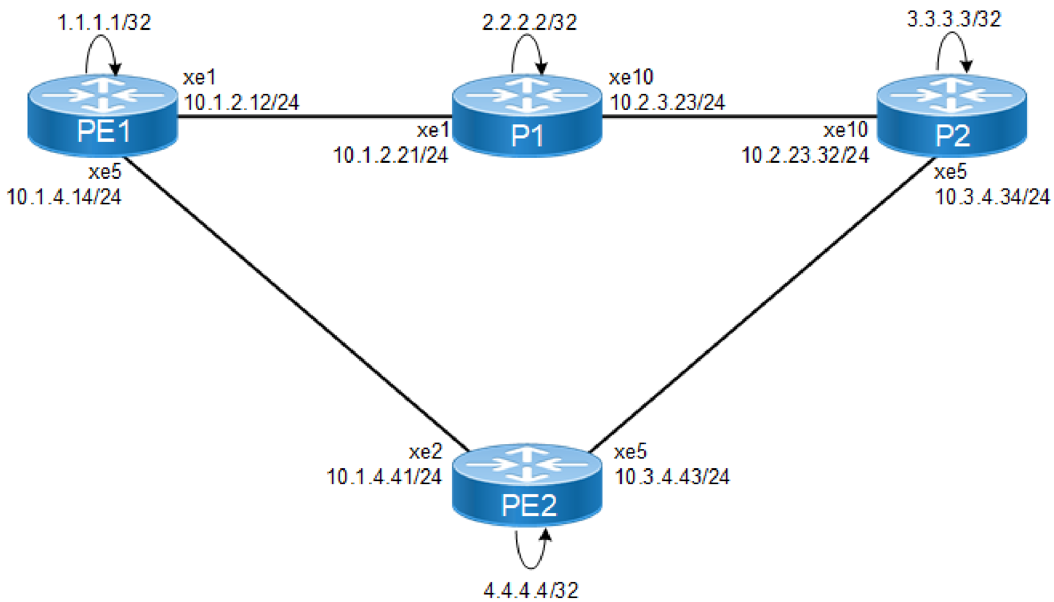

Figure 2-18: RSVP facility backup

Configuration

PE1

#configure terminal	Enter configuration mode
(config)#interface lo	Specify interface loopback for configuration
(config-if)#ip address 1.1.1.1/32 secondary	Configure ip address of loopback
(config-if)#exit	Exit interface configuration mode
(config)#interface xe1	Specify interface xe1 for configuration
(config-if)#ip address 10.1.2.12/24	Configure ip address of interface
(config)#exit	Exit interface configuration mode
(config-if)#int xe5	Specify interface xe1 for configuration
(config-if)#ip address 10.1.4.14/24	Configure ip address of loopback

(config-if)#exit	Exit configuration mode
(config)#router ospf 1	Configure the router OSPF with process id
(config-router)#router-id 1.1.1.1	Configure OSPF router-id
(config-router)#network 1.1.1.1/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.2.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#exit	Exit the configure mode
(config)#router ospf 1	Enter router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe5	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

P1

(config)#interface lo	Specify the interface (lo)
(config-if)#ip address 2.2.2.2/32 secondary	Enter the loopback ip address as secondary
(config-if)#exit	Exit the interface configure mode
(config-if)#int xe1	Specify the interface(xe1)
(config-if)#ip address 10.1.2.21/24	Configure the IP address for the interface
(config-if)#exit	Exit the interface mode
(config-if)#int xe10	Specify the interface(xe1)
(config-if)#ip address 10.2.3.23/24	Configure the IP address for the interface
(config-if)#exit	Exit the configuration mode
(config)#router ospf 1	Configure OSPF router-id
(config-router)#router-id 2.2.2.2	Configure the router id
(config-router)#network 2.2.2.2/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.2.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.2.3.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval

(config)#exit	Exit the configure mode
(config)#router ospf 1	Enter router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe10	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

P2

(config)#interface lo	Specify the interface (lo)
(config-if)#ip address 3.3.3.3/32 secondary	Enter the loopback ip address as secondary
(config-if)#exit	Exit the interface configuration mode
(config-if)#int xe10	Specify the interface(xe1)
(config-if)#ip address 10.2.3.32/24	Configure the IP address for the interface
(config-if)#exit	Exit the interface mode
(config-if)#interface xe5	Specify the interface(xe1)
(config-if)#ip address 10.3.4.34/24	Configure the IP address for the interface
(config-if)#exit	Exit the configuration mode
(config)#router ospf 1	Configure OSPF router-id
(config-router)#router-id 3.3.3.3	Configure the router id
(config-router)#network 3.3.3.3/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.3.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.2.3.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#exit	Exit the configure mode
(config)#router ospf 1	Enter router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe10	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP

(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe5	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

PE2

(config)#interface lo	Specify the interface (lo)
(config-if)#ip address 4.4.4.4/32 secondary	Enter the loopback IP address as secondary
(config-if)#exit	Exit the interface configuration mode
(config-if)#interface xe2	Specify the interface(xe1)
(config-if)#ip address 10.1.4.41/24	Configure the ip address for the interface
(config-if)#exit	Exit the interface mode
(config-if)#int xe5	Specify the interface(xe1)
(config-if)#ip address 10.3.4.43/24	Configure the ip address for the interface
(config-if)#exit	Exit the configuration mode
(config)#router ospf 1	Configure ospf router-id
(config-router)#router-id 4.4.4.4	Configure the router id
(config-router)#network 4.4.4.4/32 area 1	Define the network of the interface with area 0
(config-router)#network 10.1.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#network 10.3.4.0/24 area 1	Define the network of the interface with area 0
(config-router)#exit	Exit the configure mode
(config)#bfd interval 3 minrx 3 multiplier 3	Configure BFD interval
(config)#exit	Exit the configuration mode
(config)#router ospf 1	Exit the router OSPF mode with process id
(config-router)#bfd all-interfaces	Enable the OSPF enabled interfaces with bfd
(config-router)#exit	Exit the router mode
(config)#router rsvp	Enter router RSVP
(config-router)#exit	Exit the router configuration mode
(config)#interface xe1	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#exit	Exit the interface configuration mode
(config)#interface xe5	Enter the interface mode
(config-if)#enable-rsvp	Enable RSVP
(config-if)#label-switching	Enable label-switching
(config-if)#commit	Commit the transaction.

RSVP Path on PE1

(config)#rsvp-path primary_1	Enter the rsvp-path configuration mode with name
(config-path)#10.1.2.21 strict	Specify the first next-hop ip address
(config-path)#10.2.3.32 strict	Specify the second next-hop ip address
(config-path)#exit	Exit the rsvp-path configuration mode
#configure terminal	Enter the configuration mode
(config)#rsvp-path bypass_1	Enter the rsvp-path configuration mode with name
(config-path)#10.1.4.41 strict	Specify the first next-hop ip address
(config-path)#10.3.4.34 strict	Specify the second next-hop ip address
(config-path)#exit	Exit the rsvp-path configuration mode
#configure terminal	Enter the configuration mode
(config)#rsvp-trunk R1-R3	Enter the rsvp trunk to be created with name
(config-trunk)#primary path primary_1	Configure primary path for the trunk
(config-trunk)#to 3.3.3.3	Enter the destination ip
(config-trunk)#primary fast-reroute protection facility	Configure facility backup protection for the trunk
(config-trunk)#exit	Exit the configuration mode
(config)#rsvp-bypass B1-B8	Enter the rsvp bypass to be created with name
(config-trunk)#path bypass_1	Configure primary path for the trunk
(config-trunk)#to 3.3.3.3	Enter the destination IP
(config-if)#commit	Commit the transaction.

Validation

OSPF Neighborship

PE1

```
#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID     Pri   State            Dead Time   Address         Interface
Instance ID
2.2.2.2         1   Full/Backup     00:00:38   10.1.2.21            xe1
0
4.4.4.4         1   Full/DR          00:00:33   10.1.4.41            xe5
0
```

P1

```
#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID     Pri   State           Dead Time   Address     Interface    Instance ID
```

```
1.1.1.1          1    Full/DR        00:00:35    10.1.2.12       xe1           0
3.3.3.3          1    Full/Backup    00:00:34    10.2.3.32       xe10          0
```

P2

```
#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID     Pri   State     Dead Time   Address     Interface          Instance ID
2.2.2.2          1   Full/DR     00:00:37     10.2.3.23     xe10                 0
4.4.4.4          1   Full/Backup 00:00:39     10.3.4.43     xe5                  0
```

PE2

```
#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID    Pri   State          Dead Time   Address         Interface     Instance ID
1.1.1.1        1   Full/Backup      00:00:38      10.1.4.14      xe2            0
3.3.3.3        1    Full/DR         00:00:36      10.3.4.34      xe5            0
```

RSVP Session

PE1

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes

Ingress RSVP:
To              From            Type  LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
3.3.3.3         1.1.1.1          PRI   R1-R3-Primary                   UP    00:54:48  1
1 SE     -        24321     DEFAULT
3.3.3.3         1.1.1.1          BPS   B1-B4-Bypass                    UP    01:08:32  1
1 SE     -        24321     DEFAULT
Total 2 displayed, Up 2, Down 0.
#show rsvp bypass
Ingress RSVP:
To              From            LSPName                        State Uptime    Rt  Style
Labelin  Labelout  DSType
3.3.3.3         1.1.1.1        B1-B4-Bypass                    UP    01:09:17  1 1 SE
-        24321     DEFAULT


#show rsvp bypass protected-lsp-list
Bypass trunk: B1-B4
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id     Lsp Id     Lsp Name                 Role     Ext_tnl_id     Ingress
Egress
```

```
5001         2202      R1-R3-Primary             Ingress   1.1.1.1       1.1.1.1
3.3.3.3
Total LSP protected : 1
 Bandwidth in use : 0


#show rsvp bypass B1-B4 protected-lsp-list
Bypass trunk: B1-B4
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id     Lsp Id     Lsp Name                  Role     Ext_tnl_id     Ingress
Egress
5001         2202      R1-R3-Primary             Ingress   1.1.1.1       1.1.1.1
3.3.3.3
Total LSP protected : 1
 Bandwidth in use : 0


#show rsvp session detail
Ingress (Primary)
3.3.3.3
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R3-Primary
  Ingress FSM state: Operational
  Establishment Time: 0s 8ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  IGP-Shortcut: Disabled, LSP metric: 2
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Bypass trunk: B1-B4,  Merge Point: 10.2.3.32,  MP Label: 3
    Bypass OutLabel: 24321,  OutIntf: xe5
    Protection provided -> Type: Link, BW: Best-effort
  Label in: -,  Label out:    24321
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2202, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.1.2.21, xe1
  Path refresh: 30 seconds (RR enabled) (due in 26564 seconds)
  Resv refresh: 0 seconds (due in 0 seconds)
  Resv lifetime: 157 seconds (due in 150 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups: none
  Configured Path: primary_1 (in use)
  Configured Explicit Route Detail :
   10.1.2.21/32 strict
   10.2.3.32/32 strict
  Session Explicit Route Detail :
```

```
   10.1.2.21/32 strict
   10.2.3.32/32 strict
  Record route:
   LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
   NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
   -------------------------------------------------------------
   IP Address        Label     (LP, PU, NP, BP)
   -------------------------------------------------------------
   <self>
   10.1.2.21         24321     ( 0,  0,  0,  0)
   10.2.3.32         3         ( 0,  0,  0,  0)
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Bypass)
3.3.3.3
  From: 1.1.1.1, LSPstate: Up, LSPname: B1-B4-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 14ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  IGP-Shortcut: Disabled, LSP metric: 2
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    24321
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2203, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.1.4.41, xe5
  Path refresh: 30 seconds (RR enabled) (due in 25747 seconds)
  Resv lifetime: 157 seconds (due in 139 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: bypass_1 (in use)
  Configured Explicit Route Detail :
   10.1.4.41/32 strict
   10.3.4.34/32 strict
  Session Explicit Route Detail :
   10.1.4.41/32 strict
   10.3.4.34/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
```

```
   --------------------------------------------------------------
   <self>
   10.1.4.41
   10.3.4.34
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
  Total LSP protected : 1, Bandwidth in use : 0
```

P1

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes

Transit RSVP:
To             From           Type  LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
3.3.3.3         1.1.1.1         PRI   R1-R3-Primary                    UP    00:57:44  1
1 SE     24321    3         ELSP_CON
Total 1 displayed, Up 1, Down 0.

#show rsvp session de
Transit
3.3.3.3
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R3-Primary
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:    24321,  Label out:        3
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2202, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.2.3.32, xe10   Upstream: 10.1.2.12, xe1
  Path refresh: 30 seconds (RR enabled) (due in 26500 seconds)
  Path lifetime: 157 seconds (due in 126 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 20926 seconds)
  Resv lifetime: 157 seconds (due in 151 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups:   Received Explicit Route Detail :
   10.1.2.21/32 strict
   10.2.3.32/32 strict
```

```
  Session Explicit Route Detail :
   10.2.3.32/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   10.1.2.12         24321
   <self>
   10.2.3.32         3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

P2

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to 
Secondary
* indicates the session is active with local repair at one or more nodes

Egress RSVP:
To              From            Type  LSPName                        State Uptime    Rt 
Style  Labelin  Labelout  DSType
3.3.3.3         1.1.1.1         PRI   R1-R3-Primary                    UP    00:58:47  1 
1 SE     3        -         ELSP_CON
3.3.3.3         1.1.1.1         PRI   B1-B4-Bypass                     UP    01:12:30  1 
1 SE     3        -         ELSP_CON
Total 2 displayed, Up 2, Down 0

#show rsvp session detail
Egress
3.3.3.3
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R3-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:        3,  Label out: -
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2202, Ext-Tunnel Id: 1.1.1.1
  Upstream: 10.2.3.23, xe10
  Path lifetime: 157 seconds (due in 140 seconds)
```

```
  Resv refresh: 30 seconds (RR enabled) (due in 37780 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups:   Received Explicit Route Detail :
   10.2.3.32/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   10.1.2.12         24321
   10.2.3.23         3
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Egress
3.3.3.3
  From: 1.1.1.1, LSPstate: Up, LSPname: B1-B4-Bypass
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        3,  Label out: -
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2203, Ext-Tunnel Id: 1.1.1.1
  Upstream: 10.3.4.43, xe5
  Path lifetime: 157 seconds (due in 134 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 29222 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   10.3.4.34/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   10.1.4.14
   10.3.4.43
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
```

```
  Last Recorded Error Code: None
  Last Recorded Error Value: None
  Node where Last Recorded Error originated: None
  Trunk Type: mpls.
```

PE2

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes

Transit RSVP:
To             From            Type  LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
3.3.3.3         1.1.1.1         PRI   B1-B4-Bypass                     UP    01:14:12  1
1 SE     24321    3         ELSP_CON
Total 1 displayed, Up 1, Down 0.


#show rsvp session detail
Transit
3.3.3.3
  From: 1.1.1.1, LSPstate: Up, LSPname: B1-B4-Bypass
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    24321,  Label out:        3
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2203, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.3.4.34, xe5   Upstream: 10.1.4.14, xe2
  Path refresh: 30 seconds (RR enabled) (due in 25543 seconds)
  Path lifetime: 157 seconds (due in 146 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 17729 seconds)
  Resv lifetime: 157 seconds (due in 135 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   10.1.4.41/32 strict
   10.3.4.34/32 strict
  Session Explicit Route Detail :
   10.3.4.34/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   10.1.4.14
   <self>
   10.3.4.34
  Style: Shared Explicit Filter
```

```
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type:  ELSP_CONFIG
CLASS    DSCP_value     EXP_value
Last Recorded Error Code: None
Last Recorded Error Value: None
Node where Last Recorded Error originated: None
Trunk Type: mpls
```

Limitations

Dedicated Bypass Bandwidth

Refer the topology defined above.

Suppose we have two primary tunnels P1 (100mbps) and P2(20mbps) ingressing from R1 and egressing at R3 (path R1->R2>R3) and asking for BW protection and we have two Bypass tunnels bp1 (120mbps) and bp2(80mbps) type dedicated with same ingress and egress router taking Path R1->R4->R3. Below are the two cases defined in which we can observe different kinds of behavior.

1. Let the primary P1 and P2 come up.

CASE 1:

i) If the bypass bp1 (120mbps) comes up first it will give protection to both the primaries P1 and P2. bp2 should remain idle and will not give protection if there are no other primary tunnels asking for it.

CASE 2:

i) If the bypass bp2 (80mbps) comes up first it will give protection to only the primary P2 (20mbps) that will have satisfied protection which will not be changed until the bypass will go down.

ii) After that if bp1 (120mbps) comes it will provide protection to primary P1 (100mbps).

So in the CASE 1 after the protection has been provided to both the primary tunnels P1 and P2 by bypass bp1 if new primary tunnel P3 comes up with BW protection of 80mbps it would be given by bp2 (80mbps).

But in the CASE 2 as bp2 has only 60mbps left (20mbps is being used by P2) and it would not give protection to P3 tunnel and it will remain unprotected. To get the protection new tunnel has to have setup and hold priorities higher than other tunnels which are already been served with the bypass protection.

Secondary Tunnel

Suppose we have primary tunnel P1 (100mbps) ingressing from R1 and egressing at R3 (path R1->R2>R3) and asking for BW protection and we have Bypass tunnel bp1 (120mbps) type dedicated with same ingress and egress router taking Path R1->R4->R3. Then Bypass will start providing protection to primary P1.

If the primary went down it will start using the local protection.

After that if the secondary tunnel is provisioned, primary LSP, which is in using backup state shall continue to use backup path and will not shift over to secondary path.

Facility Bypass with Ring Topology Configuration

This section contains a complete Facility Bypass with Ring Topology configuration.

During facility bypass integration to OcNOS SP, few issues were reported when upstream and downstream interfaces of a session happens to be same (i.e. protection path is same as upstream path) and also CSPF most likely had some issues where LSP path used to formed by crossing the head node of the path.

Considering the information available in RSVP to impose restriction, bypass tunnel path crossing primary LSP node anywhere in between merge point were not considered for mapping.

Below assumption point was added in ERD and documents were updated on the line.

If protection is requested by primary session, then initial bypass matching criteria will be to ensure egress (merge point) node of bypass will be one of the nodes of primary LSP and bypass never intersect any node of primary LSP until the merge point.

The facility bypass method takes advantage of the MPLS label stack. Instead of creating a separate LSP for every backed-up LSP, a single LSP is created that serves to back up a set of LSPs. We call such an LSP tunnel a bypass tunnel. The bypass tunnel must intersect the path of the original LSP(s) somewhere downstream of the PLR. Naturally, this constrains the set of LSPs being backed up via that bypass tunnel to those that pass through some common downstream node. All LSPs that pass through the point of local repair and through this common node that do not also use the facilities involved in the bypass tunnel are candidates for this set of LSPs.

By multiple facility bypass tunnels, we mean that multiple facility bypass tunnels can be created to the same egress/MP. For a protected LSP there could be multiple candidates available. The mapping of the LSP to one of the backup tunnels has to be efficiently done so that we can extract the maximum benefit out of those backup tunnels available

Topology

Figure 2-19 displays a sample Facility Bypass with Ring topology.

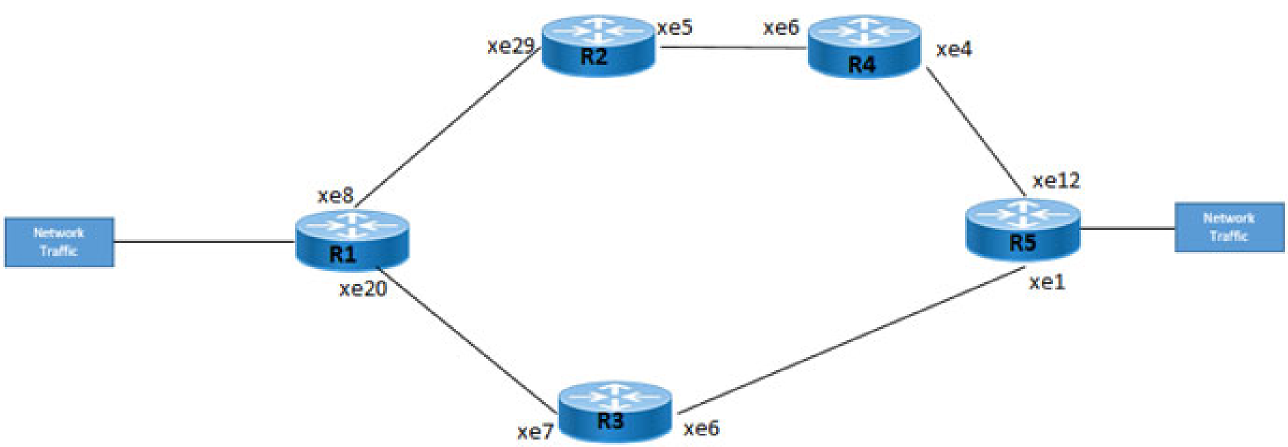

Figure 2-19: Facility Bypass with Ring Topology

Configurations

All configuration commands in the table below should be followed for each router.

R1

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/32 secondary`	Configure IP address for the loopback interface.

`(config-if)#ip router isis ISIS-IGP`	Enable IS-IS routing on an interface
`(config-if)#exit`	Exit interface mode.
`(config)#bfd interval 3 minrx 3 multiplier`	Configure BFD interval
`(config)#router-id 1.1.1.1`	Assigning router-id
`(config)#router rsvp`	Enter router mode for RSVP.
`(config-router)#exit`	Exit router configuration mode.
`(config)#interface xe8`	Specify the Interface to be configured.
`(config-if)#ip address 10.1.1.1/24`	Configure IP address for the interface.
`(config-if)#no shutdown`	Administratively bringing up the interface.
`(config-if)#label-switching`	Enable label switching on the interface
`(config-if)#isis network point-to-point`	Configure the ISIS interface network type as point to point
`(config-if)#ip router isis ISIS-IGP`	Enable IS-IS routing on an interface
`(config-if)#enable-rsvp`	Enable rsvp configuration on interface
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe20`	Specify the Interface to be configured
`(config-if)#ip address 12.1.1.1/24`	Configure IP address for the interface.
`(config-if)#no shutdown`	Administratively bringing up the interface.
`(config-if)#label-switching`	Enable label switching on the interface
`(config-if)#isis network point-to-point`	Configure the ISIS interface network type as point to point
`(config-if)#ip router isis ISIS-IGP`	Enable IS-IS routing on an interface
`(config-if)#enable-rsvp`	Enable rsvp configuration on interface
`(config-if)#exit`	Exit interface mode.
`(config)#router isis ISIS-IGP`	Create an IS-IS routing instance
`(config-router)#is-type level-1`	Configure instance as level-1only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide.
`(config-router)#mpls traffic-eng router-id 1.1.1.1`	Configure MPLS-TE unique router-id TLV.
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1
`(config-router)#capability cspf`	Enable CSPF feature for ISIS instance.
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance
`(config-router)#bfd all-interfaces`	Enable BFD for all neighbors.
`(config-router)#net 49.0000.0000.0001.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID.
`(config-router)#exit`	Exit router mode.
`(config)#rsvp-path R1-R5-PRI-001`	Create a rsvp path
`(config-path)#10.1.1.2 strict`	Configure this explicit router path as a strict hop
`(config-path)#14.1.1.3 strict`	Configure this explicit router path as a strict hop
`(config-path)#17.1.1.3 strict`	Configure this explicit router path as a strict hop
`(config-path)#exit`	Exit the rsvp-path mode
`(config)#rsvp-path R1-R5-BPS-001`	Create a rsvp path
`(config-path)#12.1.1.2 strict`	Configure this explicit router path as a strict hop

(config-path)#15.1.1.3 strict	Configure this explicit router path as a strict hop
(config-path)#exit	Exit the rsvp-path mode
(config)#rsvp-trunk R1-R5-PRI-001	Enter the trunk mode for RSVP
(config-trunk)#primary fast-reroute protection facility	Configure primary fast-reroute protection facility for a trunk.
(config-trunk)#primary fast-reroute node-protection	Configure primary fast-reroute node protection for a trunk.
(config-trunk)#primary path R1-R5-PRI-001	Configure trunk to use the defined path.
(config-trunk)#to 5.5.5.5	Specify the IPv4 egress (destination point) for the LSP
(config-path)#exit	Exit the rsvp-trunk mode
(config)#rsvp-bypass R1-R5-BPS-001	Enter the bypass mode for RSVP
(config-trunk)#path R1-R5-BPS-001	Configure path for bypass tunnel
(config-trunk)#to 5.5.5.5	Specify the IPv4 egress (destination point) for the LSP
(config-path)#exit	Exit the rsvp-bypass mode
(config)#commit	Commit the transaction.

R2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 2.2.2.2/32 secondary	Configure IP address for the loopback interface.
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#router-id 2.2.2.2	Assigning router-id
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe29	Specify the Interface to be configured.
(config-if)#ip address 10.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe5	Specify the Interface to be configured
(config-if)#ip address 14.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface

`(config-if)#exit`	Exit interface mode.
`(config)#router isis ISIS-IGP`	Create an IS-IS routing instance
`(config-router)#is-type level-1`	Configure instance as level-1only routing.
`(config-router)#metric-style wide`	Configure the new style of metric type as wide.
`(config-router)#mpls traffic-eng router-id 2.2.2.2`	Configure MPLS-TE unique router-id TLV.
`(config-router)#mpls traffic-eng level-1`	Enable MPLS-TE in is-type Level-1
`(config-router)#capability cspf`	Enable CSPF feature for ISIS instance.
`(config-router)#dynamic-hostname`	Configure the hostname to be advertised for an ISIS instance
`(config-router)#bfd all-interfaces`	Enable BFD for all neighbors.
`(config-router)#net 49.0000.0000.0002.00`	Set a Network Entity Title for this instance, specifying the area address and the system ID.
`(config-router)#exit`	Exit router mode.
`(config)#commit`	Commit the transaction.

R3

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 3.3.3.3/32 secondary`	Configure IP address for the loopback interface.
`(config-if)#ip router isis ISIS-IGP`	Enable IS-IS routing on an interface
`(config-if)#exit`	Exit interface mode.
`(config)#router-id 3.3.3.3`	Assigning router-id
`(config)#bfd interval 3 minrx 3 multiplier`	Configure BFD interval
`(config)#router rsvp`	Enter router mode for RSVP.
`(config-router)#exit`	Exit router configuration mode.
`(config)#interface xe7`	Specify the Interface to be configured.
`(config-if)#ip address 12.1.1.2/24`	Configure IP address for the interface.
`(config-if)#no shutdown`	Administratively bringing up the interface.
`(config-if)#label-switching`	Enable label switching on the interface
`(config-if)#isis network point-to-point`	Configure the ISIS interface network type as point to point
`(config-if)#ip router isis ISIS-IGP`	Enable IS-IS routing on an interface
`(config-if)#enable-rsvp`	Enable rsvp configuration on interface
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe6`	Specify the Interface to be configured
`(config-if)#ip address 15.1.1.2/24`	Configure IP address for the interface.
`(config-if)#no shutdown`	Administratively bringing up the interface.
`(config-if)#label-switching`	Enable label switching on the interface
`(config-if)#isis network point-to-point`	Configure the ISIS interface network type as point to point
`(config-if)#ip router isis ISIS-IGP`	Enable IS-IS routing on an interface
`(config-if)#enable-rsvp`	Enable rsvp configuration on interface
`(config-if)#exit`	Exit interface mode.

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(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config-router)#is-type level-1	Configure instance as level-1only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 3.3.3.3	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0003.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.

R4

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 4.4.4.4/32 secondary	Configure IP address for the loopback interface.
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#router-id 4.4.4.4	Assigning router-id
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe4	Specify the Interface to be configured.
(config-if)#ip address 17.1.1.2/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe6	Specify the Interface to be configured
(config-if)#ip address 14.1.1.3/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance

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(config-router)#is-type level-1	Configure instance as level-1only routing.
(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 4.4.4.4	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0004.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.

R5

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 5.5.5.5/32 secondary	Configure IP address for the loopback interface.
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#exit	Exit interface mode.
(config)#router-id 5.5.5.5	Assigning router-id
(config)#bfd interval 3 minrx 3 multiplier	Configure BFD interval
(config)#router rsvp	Enter router mode for RSVP.
(config-router)#exit	Exit router configuration mode.
(config)#interface xe12	Specify the Interface to be configured.
(config-if)#ip address 17.1.1.3/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Specify the Interface to be configured
(config-if)#ip address 15.1.1.3/24	Configure IP address for the interface.
(config-if)#no shutdown	Administratively bringing up the interface.
(config-if)#label-switching	Enable label switching on the interface
(config-if)#isis network point-to-point	Configure the ISIS interface network type as point to point
(config-if)#ip router isis ISIS-IGP	Enable IS-IS routing on an interface
(config-if)#enable-rsvp	Enable rsvp configuration on interface
(config-if)#exit	Exit interface mode.
(config)#router isis ISIS-IGP	Create an IS-IS routing instance
(config-router)#is-type level-1	Configure instance as level-1only routing.

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(config-router)#metric-style wide	Configure the new style of metric type as wide.
(config-router)#mpls traffic-eng router-id 5.5.5.5	Configure MPLS-TE unique router-id TLV.
(config-router)#mpls traffic-eng level-1	Enable MPLS-TE in is-type Level-1
(config-router)#capability cspf	Enable CSPF feature for ISIS instance.
(config-router)#dynamic-hostname	Configure the hostname to be advertised for an ISIS instance
(config-router)#bfd all-interfaces	Enable BFD for all neighbors.
(config-router)#net 49.0000.0000.0005.00	Set a Network Entity Title for this instance, specifying the area address and the system ID.
(config-router)#exit	Exit router mode.
(config)#commit	Commit the transaction.

Validation

RSVP Session

Validate that the RSVP Session is up.

R1:

```
R1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Type    LSPName                       State Uptime    Rt
Style  Labelin  Labelout  DSType
5.5.5.5         1.1.1.1          PRI     R1-R5-PRI-001-Primary           UP    00:49:18
1 1 SE     -        52480     DEFAULT
5.5.5.5         1.1.1.1          BPS     R1-R5-BPS-001-Bypass            UP    05:24:23
1 1 SE     -        25600     DEFAULT
Total 2 displayed, Up 2, Down 0.

R1#show rsvp session detail
Ingress (Primary)
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
  Ingress FSM state: Operational
  Establishment Time: 322s 925ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 30
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Node
  Fast-Reroute Hop limit: 255
```

```
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Bypass trunk: R1-R5-BPS-001,  Merge Point: 17.1.1.3,  MP Label: 25600
    Bypass OutLabel: 25600,  OutIntf: xe20
    Protection provided -> Type: Node, BW: Best-effort
  Label in: -,  Label out:    52480,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 10.1.1.2, xe8
  Path refresh: 30 seconds (RR enabled) (due in 27023 seconds)
  Resv refresh: 0 seconds (due in 0 seconds)
  Resv lifetime: 157 seconds (due in 128 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups: none
  Configured Path: R1-R5-PRI-001 (in use)
  Configured Explicit Route Detail :
   10.1.1.2/32 strict
   14.1.1.3/32 strict
   17.1.1.3/32 strict
  Session Explicit Route Detail :
   10.1.1.2/32 strict
   14.1.1.3/32 strict
   17.1.1.3/32 strict
  Record route:
   LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
   NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
   -------------------------------------------------------------
   IP Address         Label      (LP, PU, NP, BP)
   -------------------------------------------------------------
   <self>
   10.1.1.2           52480      ( 0,  0,  0,  0)
   14.1.1.3           52480      ( 0,  0,  0,  0)
   17.1.1.3           25600      ( 0,  0,  0,  0)
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
Ingress (Bypass)
5.5.5.5
```

```
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 4ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 20
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    25600,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 12.1.1.2, xe20
  Path refresh: 30 seconds (RR enabled) (due in 10514 seconds)
  Resv lifetime: 157 seconds (due in 141 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: R1-R5-BPS-001 (in use)
  Configured Explicit Route Detail :
   12.1.1.2/32 strict
   15.1.1.3/32 strict
  Session Explicit Route Detail :
   12.1.1.2/32 strict
   15.1.1.3/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   <self>
   12.1.1.2
   15.1.1.3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : RSVP System error (23), Value : N/A (0)
    Originated Node : 15.1.1.3, Recorded Time : 2023 May 16 08:52:51
  Trunk Type: mpls
  Total LSP protected : 1, Bandwidth in use : 0
```

R2:

```
R2#show rsvp session
```

```
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
To             From           Type    LSPName                        State Uptime    Rt
Style  Labelin  Labelout  DSType
5.5.5.5         1.1.1.1         PRI     R1-R5-PRI-001-Primary           UP    00:49:59
1 1 SE     52480    52480     ELSP_CON
Total 1 displayed, Up 1, Down 0.

R2#show rsvp session detail
Transit
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Node
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:    52480,  Label out:    52480,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 14.1.1.3, xe5   Upstream: 10.1.1.1, xe29
  Path refresh: 30 seconds (RR enabled) (due in 27004 seconds)
  Path lifetime: 157 seconds (due in 130 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 19943 seconds)
  Resv lifetime: 157 seconds (due in 141 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups:   Received Explicit Route Detail :
   10.1.1.2/32 strict
   14.1.1.3/32 strict
   17.1.1.3/32 strict
  Session Explicit Route Detail :
   14.1.1.3/32 strict
   17.1.1.3/32 strict
  Record route:
   ------------------------------------------------------------
   IP Address        Label
   ------------------------------------------------------------
   10.1.1.1          52480
   <self>
   14.1.1.3          52480
   17.1.1.3          25600
```

```
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
```

R3:

```
R3#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
To             From           Type    LSPName                       State Uptime    Rt
Style  Labelin  Labelout  DSType
5.5.5.5         1.1.1.1         PRI     R1-R5-BPS-001-Bypass            UP    05:25:48
1 1 SE     25600    3          ELSP_CON
Total 1 displayed, Up 1, Down 0.

R3#show rsvp session detail
Transit
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    25600,  Label out:       3,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 15.1.1.3, xe6   Upstream: 12.1.1.1, xe7
  Path refresh: 30 seconds (RR enabled) (due in 10445 seconds)
  Path lifetime: 157 seconds (due in 155 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 24008 seconds)
  Resv lifetime: 157 seconds (due in 140 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   12.1.1.2/32 strict
   15.1.1.3/32 strict
  Session Explicit Route Detail :
   15.1.1.3/32 strict
  Record route:
   -------------------------------------------------------------
```

```
   IP Address        Label
   ------------------------------------------------------------
   12.1.1.1
   <self>
   15.1.1.3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
R3#
```

R4:

```
R4#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
To             From            Type    LSPName                       State Uptime    Rt
Style  Labelin  Labelout  DSType
5.5.5.5         1.1.1.1         PRI     R1-R5-PRI-001-Primary           UP    00:51:13
1 1 SE     52480    25600     ELSP_CON
Total 1 displayed, Up 1, Down 0.

R4#show rsvp session detail
Transit
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Node
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:    52480,  Label out:    25600,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 17.1.1.3, xe4   Upstream: 14.1.1.2, xe6
  Path refresh: 30 seconds (RR enabled) (due in 26908 seconds)
  Path lifetime: 157 seconds (due in 148 seconds)
```

```
  Resv refresh: 30 seconds (RR enabled) (due in 37164 seconds)
  Resv lifetime: 157 seconds (due in 144 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups:   Received Explicit Route Detail :
   14.1.1.3/32 strict
   17.1.1.3/32 strict
  Session Explicit Route Detail :
   17.1.1.3/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   10.1.1.1          52480
   14.1.1.2          52480
   <self>
   17.1.1.3          25600
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
```

R5:

```
R5#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Egress RSVP:
To             From           Type    LSPName                       State Uptime    Rt
Style  Labelin  Labelout  DSType
5.5.5.5         1.1.1.1         PRI     R1-R5-PRI-001-Primary           UP    00:51:45
1 1 SE     25600    -         ELSP_CON
5.5.5.5         1.1.1.1         PRI     R1-R5-BPS-001-Bypass            UP    05:26:50
1 1 SE     3        -         ELSP_CON
Total 2 displayed, Up 2, Down 0.

R5#show rsvp session detail
Egress
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-PRI-001-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
```

```
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Node
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:    25600,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 17.1.1.2, xe12
  Path lifetime: 157 seconds (due in 126 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 28434 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups:   Received Explicit Route Detail :
   17.1.1.3/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   10.1.1.1          52480
   14.1.1.2          52480
   17.1.1.2          25600
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
Egress
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        3,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 15.1.1.2, xe1
  Path lifetime: 157 seconds (due in 141 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 927 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
```

```
  Admin Groups:   Received Explicit Route Detail :
   15.1.1.3/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   12.1.1.1
   15.1.1.2
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
```

RSVP Bypass

Validate that the RSVP bypass session is up.

R1:

```
R1#show rsvp bypass
Ingress RSVP:
To               From           LSPName                        State Uptime    Rt  Style
Labelin  Labelout  DSType
5.5.5.5          1.1.1.1        R1-R5-BPS-001-Bypass            UP    05:27:41  1 1 SE
-        25600     DEFAULT
```

To validate RSVP bypass session details:

```
R1#show rsvp bypass detail
Ingress (Bypass)
5.5.5.5
  From: 1.1.1.1, LSPstate: Up, LSPname: R1-R5-BPS-001-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 4ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 20
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    25600,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2205, Ext-Tunnel Id: 1.1.1.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 12.1.1.2, xe20
  Path refresh: 30 seconds (RR enabled) (due in 10319 seconds)
```

```
  Resv lifetime: 157 seconds (due in 126 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: R1-R5-BPS-001 (in use)
  Configured Explicit Route Detail :
   12.1.1.2/32 strict
   15.1.1.3/32 strict
  Session Explicit Route Detail :
   12.1.1.2/32 strict
   15.1.1.3/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   <self>
   12.1.1.2
   15.1.1.3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 9216
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : RSVP System error (23), Value : N/A (0)
    Originated Node : 15.1.1.3, Recorded Time : 2023 May 16 08:52:51
  Trunk Type: mpls
  Total LSP protected : 1, Bandwidth in use : 0
```

To validate RSVP bypass Protected-lsp-list:

```
R1#show rsvp bypass protected-lsp-list
Bypass trunk: R1-R5-BPS-001
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id     Lsp Id     Lsp Name                 Role     Ext_tnl_id     Ingress
Egress
5001         2201      R1-R5-PRI-001-Primary       Ingress   1.1.1.1       1.1.1.1
5.5.5.5
Total LSP protected : 1
 Bandwidth in use : 0
```

CHAPTER 3 RSVP-Multipath Configuration

RSVP multipath provides multiple paths to reach the destination. RSVP services (L2 VPN, L3 VPN, LU, mapped route, etc.) can be mapped to RSVP multipath so that traffic is load-balanced. At ingress node the traffic is load-balanced based on the configured hash (L3 src/dest IP/port, L2 src/dst mac, or in-label if intermediate Autonomous segments). Each LSP path within multipath group can provide individual protection for each path (facility, 1-to-1, secondary). Each tunnel path in multipath group cost may vary (can have different hop, with consideration for load-balancing the traffic). Each member can have the backup protection as other multipath member path or outside the multipath member path.

Topology

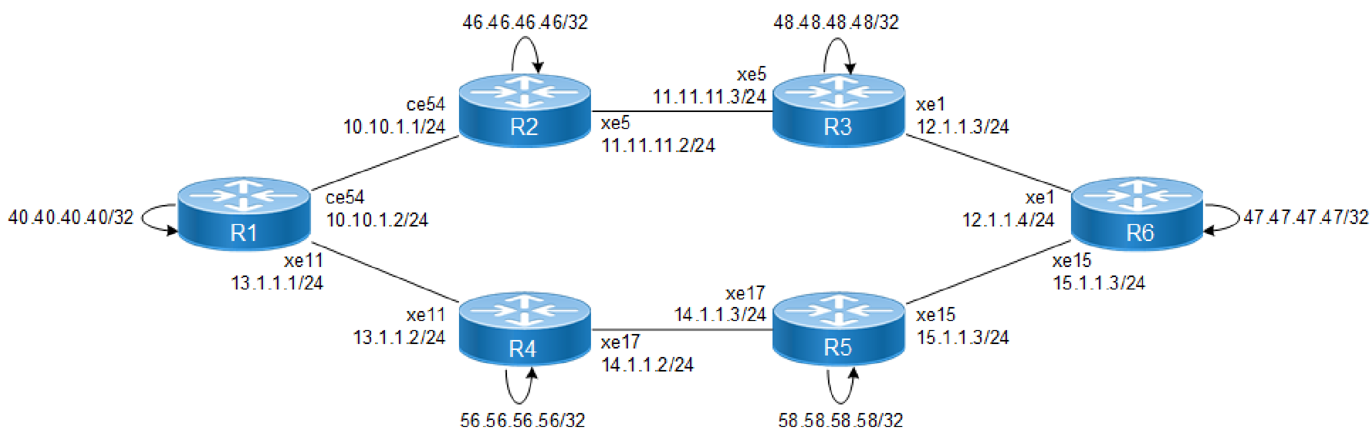

Figure 3-20: RSVP-Multipath Topology

Configuration

R1

`#configure terminal`	Enter configure mode.
`(config)#hardware-profile statistics tunnel-lif enable`	Configure hardware-profile statistics
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 40.40.40.40/32 secondary`	Set a secondary IP address of the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#router rsvp`	Enter Configure Router mode.
`(config-router)#router-id 40.40.40.40`	Set the router ID to IP address 40.40.40.40
`(config-router)#exit`	Exit Router mode.
`(config)#interface xe1`	Enter interface mode.
`(config-if)#ip address 10.10.1.1/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.

(config-if)#exit	Exit interface mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 13.1.1.1/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 40.40.40.40	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.1.1.0/24 area 0	Define the network (10.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 13.1.1.0/24 area 0	Define the network (13.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 40.40.40.40/32 area 0	Set the IP address of the loopback interface to 40.40.40.40/32.
(config-router)#exit	Exit Router mode.
(config)#rsvp-path path1 mpls	Enter the path mode for RSVP path1.
(config-path)#10.1.1.2 strict	Configure this explicit route path as a strict hop.
(config-path)#11.1.1.3 strict	Configure this explicit route path as a strict hop.
(config-path)#12.1.1.4 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-path path2 mpls	Enter the path mode for RSVP path2.
(config-path)#13.1.1.2 strict	Configure this explicit route path as a strict hop.
(config-path)#14.1.1.3 strict	Configure this explicit route path as a strict hop.
(config-path)#15.1.1.4 strict	Configure this explicit route path as a strict hop.
(config)#exit	Exit the path mode.
(config)#rsvp-trunk t1 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#primary path path1	Configure trunk t1 to use the defined path.
(config-trunk)#from 40.40.40.40	Specify the IPv4 ingress (source point) for the LSP.
(config-trunk)#to 47.47.47.47	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#exit	Exit from trunk mode.
(config)#rsvp-trunk t2 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#primary path path2	Configure trunk t2 to use the defined path.
(config-trunk)#from 40.40.40.40	Specify the IPv4 egress (source point) for the LSP.
(config-trunk)#to 47.47.47.47	Specify the IPv4 ingress (destination point) for the LSP.
(config-trunk)#exit	Exit from trunk mode.
(config)#rsvp-multipath test	Configure RSVP Multipath group.
(config-multipath)#to 47.47.47.47	Configure a mandatory destination FEC(egress router).
(config-multipath)#description "my-group"	Configure description to RSVP Multipath group.
(config-multipath)#exit	Exit from RSVP Multipath mode.
(config)#rsvp-trunk t1 ipv4	Enter the trunk mode for rsvp.

(config-trunk)#multipath-group test	Configure RSVP Multipath group to trunk t1.
(config-trunk)#exit	Exit from trunk mode.
(config)#rsvp-trunk t2 ipv4	Enter the trunk mode for rsvp.
(config-trunk)#multipath-group test	Configure RSVP Multipath group to trunk t2.
(config-trunk)#exit	Exit from trunk mode.
(config)#commit	Commit all the configurations.

R2

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 46.46.46.46/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 10.10.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe5	Enter interface mode.
(config-if)#ip address 11.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 46.46.46.46	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.1.1.0/24 area 0	Define the network (10.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 11.1.1.0/24 area 0	Define the network (11.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 46.46.46.46/32 area 0	Set the IP address of the loopback interface to 46.46.46.46/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R3

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.

(config-if)#ip address 48.48.48.48/32 secondary	Set a secondary IP address of the interface.
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 12.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe5	Enter interface mode.
(config-if)#ip address 11.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 48.48.48.48	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 11.1.1.0/24 area 0	Define the network (11.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 12.1.1.0/24 area 0	Define the network (12.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 48.48.48.48/32 area 0	Set the IP address of the loopback interface to 48.48.48.48/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R4

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 56.56.56.56/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe11	Enter interface mode.
(config-if)#ip address 13.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe17	Enter interface mode.

(config-if)#ip address 14.1.1.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 56.56.56.56	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 13.1.1.0/24 area 0	Define the network (13.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 14.1.1.0/24 area 0	Define the network (14.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 56.56.56.56/32 area 0	Set the IP address of the loopback interface to 56.56.56.56/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R5

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 58.58.58.58/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 15.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe17	Enter interface mode.
(config-if)#ip address 14.1.1.3/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 58.58.58.58	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 15.1.1.0/24 area 0	Define the network (15.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 14.1.1.0/24 area 0	Define the network (14.1.1.0/24) on which OSPF runs and associate the area ID (0).

(config-router)#network 58.58.58.58/32 area 0	Set the IP address of the loopback interface to 58.58.58.58/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

R6

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 47.47.47.47/32 secondary	Set a secondary IP address of the interface
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe1	Enter interface mode.
(config-if)#ip address 12.1.1.4/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe15	Enter interface mode.
(config-if)#ip address 15.1.1.4/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#router ospf 1	Configure the Routing process and specify the Process ID (1). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 47.47.47.47	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 12.1.1.0/24 area 0	Define the network (12.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 15.1.1.0/24 area 0	Define the network (15.1.1.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 47.47.4747/32 area 0	Set the IP address of the loopback interface to 47.47.47.47/32.
(config-router)#exit	Exit Router mode.
(config)#commit	Commit all the configurations.

Validation

R1

```
#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 1 VRF(default):
```

```
Neighbor ID     Pri   State          Dead Time   Address        Interface
Instance ID
46.46.46.46      1   Full/DR       00:00:38   10.1.1.2      ce54
0
56.56.56.56      1   Full/DR       00:00:37   13.1.1.2      xe11
0

#show rsvp session

Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To               From             Type    LSPName    State Uptime    Rt  Style
Labelin  Labelout  DSType
47.47.47.47     40.40.40.40     PRI     t1-Primary   UP    00:01:46  1 1 SE
-        24320     DEFAULT
47.47.47.47     40.40.40.40     PRI     t2-Primary   UP    00:01:46  1 1 SE
-        24320     DEFAULT
Total 2 displayed, Up 2, Down 0.

#show rsvp multipath

RSVP-multipath Name : test,  ID : 101
  Description : "my-group"
  Member count : 2,  Egress : 47.47.47.47/32
  Member details :
  ----------------
  Trunk-ID   Trunk-name                 Status
  5001       t1                         active
  5002       t2                         active


#show mpls rsvp-multipath
Codes: > - installed FTN, * - selected FTN, t - tunnel, R - RSVP-TE FTN

Multipath Name : test,  ID : 101,  Nhlfe Ix : 4
  Active member count : 2,  FEC : 47.47.47.47/32
  Active member details :
  -----------------------
  Index  Code     FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label
Out-Intf    ELC   Nexthop
  1      R(t)>    1        3         5001        Yes   LSP_DEFAULT  24320
ce54        No    10.1.1.2
  2      R(t)>    2        5         5002        Yes   LSP_DEFAULT  24320
xe11        No    13.1.1.2

#show mpls counters rsvp multipath-name test
Tunnel-id 5001 Extended Tunnel-ID 40.40.40.40 Egress 47.47.47.47
 lsp-name : t1-Primary                                   [Ingress]
 lsp-ingress : 40.40.40.40      lsp-id : 2201
 Rx pkts : n/a                  Rx bytes : n/a
 Tx pkts : 864364               Tx bytes : 1298276230

Tunnel-id 5002 Extended Tunnel-ID 40.40.40.40 Egress 47.47.47.47
```

```
 lsp-name : t2-Primary                                 [Ingress]
 lsp-ingress : 40.40.40.40      lsp-id : 2202
 Rx pkts : n/a                  Rx bytes : n/a
 Tx pkts : 864366               Tx bytes : 1298277732

#show mpls ftn-table
 Primary FTN entry with FEC: 47.47.47.47/32, id: 1, row status: Active,
Tunnel-Policy: N/A
  Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0,
Incoming DSCP: none
  Tunnel id: 5001, Protected LSP id: 2201, QoS Resource id: 2, Description:
t1, Color: 0
  Multipath group: test
     Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
      Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 3, owner: RSVP, Stale: NO, out intf: ce54, out
label: 24320
    Nexthop addr: 10.1.1.2        cross connect ix: 3, op code: Push


 Primary FTN entry with FEC: 47.47.47.47/32, id: 2, row status: Active,
Tunnel-Policy: N/A
  Owner: RSVP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0,
Incoming DSCP: none
  Tunnel id: 5002, Protected LSP id: 2202, QoS Resource id: 3, Description:
t2, Color: 0
  Multipath group: test
     Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5
      Owner: RSVP, Persistent: No, Admin Status: Up, Oper Status: Up
       Out-segment with ix: 5, owner: RSVP, Stale: NO, out intf: xe11, out
label: 24320
    Nexthop addr: 13.1.1.2        cross connect ix: 4, op code: Push

#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN,
       B - BGP FTN, K - CLI FTN, t - tunnel, P - SR Policy FTN,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
(m) - FTN mapped over multipath transport

Code    FEC                 FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type
Out-Label    Out-Intf    ELC   Nexthop
R(t)>   47.47.47.47/32      1         3         5001        Yes   LSP_DEFAULT
24320        ce54        No    10.1.1.2
R(t)>   47.47.47.47/32      2         5         5002        Yes   LSP_DEFAULT
24320        xe11        No    13.1.1.2


#show rsvp session detail
Egress
40.40.40.40
  From: 47.47.47.47, LSPstate: Up, LSPname: PE2-PE1-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    24960,  Label out: -,
  Tspec rate: 0k, Fspec rate: 0k
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 47.47.47.47
```

```
    Bind value: 0, Oper state: NA, Alloc mode: NA
    Upstream: 13.1.1.2, xe11
    Path lifetime: 157 seconds (due in 146 seconds)
    Resv refresh: 30 seconds (RR enabled) (due in 34571 seconds)
    RRO re-use as ERO: Disabled
    Label Recording: Disabled
    Admin Groups:   Received Explicit Route Detail :
     13.1.1.1/32 strict
    Record route:
     -------------------------------------------------------------
     IP Address        Label
     -------------------------------------------------------------
     15.1.1.4
     14.1.1.3
     13.1.1.2
     <self>
    Style: Shared Explicit Filter
    Traffic type: controlled-load
    Minimum Path MTU: 1500
    LSP Type:  ELSP_CONFIG
    CLASS    DSCP_value     EXP_value
    Current Error:
      Code : None, Value : None
      Originated Node : None, Recorded Time : N/A
    Trunk Type: mpls
  Ingress (Primary)
  47.47.47.47
    From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
    Ingress FSM state: Operational
    Establishment Time: 0s 22ms
    Setup priority: 7, Hold priority: 0
    CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
    LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
    IGP-Shortcut: Disabled, LSP metric: 3
    LSP Protection: None
    Label in: -,  Label out:    24320,
    Tspec rate: 0k, Fspec rate: 0k
    Policer: Not Configured
    Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
    Bind value: 0, Oper state: NA, Alloc mode: NA
    Downstream: 10.1.1.2, ce54
    Path refresh: 30 seconds (RR enabled) (due in 29859 seconds)
    Resv lifetime: 157 seconds (due in 149 seconds)
    Retry count: 0, intrvl: 30 seconds
    RRO re-use as ERO: Disabled
    Label Recording: Disabled
    Admin Groups: none
    Configured Path: path1 (in use)
    Configured Explicit Route Detail :
     10.1.1.2/32 strict
     11.1.1.3/32 strict
     12.1.1.4/32 strict
    Session Explicit Route Detail :
     10.1.1.2/32 strict
     11.1.1.3/32 strict
     12.1.1.4/32 strict
    Record route:
```

```
     ------------------------------------------------------------
     IP Address        Label
     ------------------------------------------------------------
     <self>
     10.1.1.2
     11.1.1.3
     12.1.1.4
    Style: Shared Explicit Filter
    Traffic type: controlled-load
    Minimum Path MTU: 1500
    Current Error:
      Code : None, Value : None
      Originated Node : None, Recorded Time : N/A
    Last Signaled Error:
      Code : None, Value : None
      Originated Node : None, Recorded Time : N/A
    Trunk Type: mpls
  Ingress (Primary)
  47.47.47.47
    From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
    Ingress FSM state: Operational
    Establishment Time: 0s 30ms
    Setup priority: 7, Hold priority: 0
    CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
    LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
    IGP-Shortcut: Disabled, LSP metric: 3
    LSP Protection: None
    Label in: -,  Label out:    24320,
    Tspec rate: 0k, Fspec rate: 0k
    Policer: Not Configured
    Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
    Bind value: 0, Oper state: NA, Alloc mode: NA
    Downstream: 13.1.1.2, xe11
    Path refresh: 30 seconds (RR enabled) (due in 29850 seconds)
    Resv lifetime: 157 seconds (due in 146 seconds)
    Retry count: 0, intrvl: 30 seconds
    RRO re-use as ERO: Disabled
    Label Recording: Disabled
    Admin Groups: none
    Configured Path: path2 (in use)
    Configured Explicit Route Detail :
     13.1.1.2/32 strict
     14.1.1.3/32 strict
     15.1.1.4/32 strict
    Session Explicit Route Detail :
     13.1.1.2/32 strict
     14.1.1.3/32 strict
     15.1.1.4/32 strict
    Record route:
     ------------------------------------------------------------
     IP Address        Label
     ------------------------------------------------------------
     <self>
     13.1.1.2
     14.1.1.3
     15.1.1.4
    Style: Shared Explicit Filter
```

```
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls


#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
        K - CLI ILM, T - MPLS-TP, s - Stitched ILM
       S - SNMP, L - LDP, R - RSVP, C - CRLDP
       B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
       O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
       P - SR Policy, U - unknown

Code    FEC/VRF/L2CKT    ILM-ID      In-Label    Out-Label   In-Intf    Out-
Intf/VRF      Nexthop                  LSP-Type
   B>   vrf-PE1           1          24320       Nolabel     N/A        vrf-
PE1          N/A                     LSP_DEFAULT
  R>  40.40.40.40/32    2        24960      Nolabel    N/A      N/A
127.0.0.1                ELSP_CONFIG



R2#show ip ospf neighbor

Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID  Pri State       Dead Time  Address   Interface  Instance ID
40.40.40.40   1  Full/Backup 00:00:37   10.10.1.1  xe1          0
48.48.48.48   1  Full/Backup 00:00:34   11.1.1.3   xe12         0

R2#show rsvp session

Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Transit RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DSType
47.47.47.47 40.40.40.40 PRI t1-Primary UP 00:14:13 1 1 SE 25600 25600 ELSP_CON
Total 1 displayed, Up 1, Down 0.
R2#
R2#
R2#
R2#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Transit upstream state: Operational, downstream state: Operational
```

```
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: 25600,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 11.1.1.3, xe12 Upstream: 10.10.1.1, xe1
Path refresh: 30 seconds (RR enabled) (due in 29011 seconds)
Path lifetime: 157 seconds (due in 133 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 32105 seconds)
Resv lifetime: 157 seconds (due in 133 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
10.10.1.2/32 strict
11.1.1.3/32 strict
12.1.1.4/32 strict
Session Explicit Route Detail :
11.1.1.3/32 strict
12.1.1.4/32 strict
Record route:
-------------------------------------------------------------
IP Address Label
-------------------------------------------------------------
10.10.1.1
<self>
11.1.1.3
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R2#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
P - SR Policy, U - unknown
LDP ilm-ecmp - disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 25600 25600 N/A xe12 11.1.1.3 Yes ELSP_CONFIG
R3#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
46.46.46.46 1 Full/DR 00:00:31 11.1.1.2 xe40 0
47.47.47.47 1 Full/Backup 00:00:32 12.1.1.4 xe6
R3#show rsvp session
```

```
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Transit RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DSType
47.47.47.47 40.40.40.40 PRI t1-Primary UP 00:20:52 1 1 SE 25600 25600 ELSP_CON
Total 1 displayed, Up 1, Down 0.
R3#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: 25600,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.4, xe1 Upstream: 11.1.1.2, xe5
Path refresh: 30 seconds (RR enabled) (due in 28622 seconds)
Path lifetime: 157 seconds (due in 151 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 41536 seconds)
Resv lifetime: 157 seconds (due in 141 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
11.1.1.3/32 strict
12.1.1.4/32 strict
Session Explicit Route Detail :
12.1.1.4/32 strict
Record route:
-------------------------------------------------------------
IP Address Label
-------------------------------------------------------------
10.10.1.1
11.1.1.2
<self>
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R3# R3#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
```

```
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: 25600,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.4, xe6 Upstream: 11.1.1.2, xe40
Path refresh: 30 seconds (RR enabled) (due in 28622 seconds)
Path lifetime: 157 seconds (due in 151 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 41536 seconds)
Resv lifetime: 157 seconds (due in 141 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
11.1.1.3/32 strict
12.1.1.4/32 strict
Session Explicit Route Detail :
12.1.1.4/32 strict
Record route:
-------------------------------------------------------------
IP Address Label
-------------------------------------------------------------
10.10.1.1
11.1.1.2
<self>
12.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R3#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
P - SR Policy, U - unknown
LDP ilm-ecmp - disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 25600 25600 N/A xe6 12.1.1.4 Yes ELSP_CONFIG
R4:
R4#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
40.40.40.40 1 Full/Backup 00:00:33 13.1.1.1 xe2 0
58.58.58.58 1 Full/DR 00:00:39 14.1.1.3 xe3 0

R4#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
```

```
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Transit RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DSType
47.47.47.47 40.40.40.40 PRI t2-Primary UP 00:54:24 1 1 SE 24320 52480 ELSP_CON
Total 1 displayed, Up 1, Down 0.
R4#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 24320, Label out: 52480,
Tspec rate: 0k, Fspec rate: 0k
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 14.1.1.3, xe3 Upstream: 13.1.1.1, xe2
Path refresh: 30 seconds (RR enabled) (due in 26617 seconds)
Path lifetime: 157 seconds (due in 143 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 36430 seconds)
Resv lifetime: 157 seconds (due in 143 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
13.1.1.2/32 strict
14.1.1.3/32 strict
15.1.1.4/32 strict
Session Explicit Route Detail :
14.1.1.3/32 strict
15.1.1.4/32 strict
Record route:
-------------------------------------------------------------
IP Address Label
-------------------------------------------------------------
13.1.1.1
<self>
14.1.1.3
15.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls R4#
R4#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
```

```
P - SR Policy, U - unknown
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop LSP-
Type
R> 47.47.47.47/32 1 24320 52480 N/A xe3 14.1.1.3 ELSP_CONFIG
R5#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
56.56.56.56 1 Full/Backup 00:00:39 14.1.1.2 xe42 0
47.47.47.47 1 Full/DR 00:00:38 15.1.1.4 xe39 0
R5#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Transit RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DSType
47.47.47.47 40.40.40.40 PRI t2-Primary UP 00:59:48 1 1 SE 52480 25601 ELSP_CON
Total 1 displayed, Up 1, Down 0.
R5#show rsvp session detail
Transit
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
Transit upstream state: Operational, downstream state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 52480, Label out: 25601,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 15.1.1.4, xe39 Upstream: 14.1.1.2, xe42
Path refresh: 30 seconds (RR enabled) (due in 26344 seconds)
Path lifetime: 157 seconds (due in 149 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 37267 seconds)
Resv lifetime: 157 seconds (due in 132 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
14.1.1.3/32 strict
15.1.1.4/32 strict
Session Explicit Route Detail :
15.1.1.4/32 strict
Record route:
-------------------------------------------------------------
IP Address Label
-------------------------------------------------------------
13.1.1.1
14.1.1.2

<self>
15.1.1.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
```

```
CLASS DSCP_value EXP_value
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R5#show mpls ilm-table
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
U - unknown
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 52480 25601 N/A xe39 15.1.1.4 Yes ELSP_CONFIG
R5#
R5#


R6:

R6#show ip ospf neighbor
Total number of full neighbors: 2
OSPF process 1 VRF(default):
Neighbor ID Pri State Dead Time Address Interface Instance ID
48.48.48.48 1 Full/DR 00:00:30 12.1.1.3 xe6 0
58.58.58.58 1 Full/Backup 00:00:33 15.1.1.3 xe5 0
R6#show rsvp session
Type : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS -
Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary
Egress RSVP:
To From Type LSPName State Uptime Rt Style Labelin Labelout DSType
47.47.47.47 40.40.40.40 PRI t1-Primary UP 01:05:33 1 1 SE 25600 - ELSP_CON
47.47.47.47 40.40.40.40 PRI t2-Primary UP 01:04:57 1 1 SE 25601 - ELSP_CON
Total 2 displayed, Up 2, Down 0.
R6#
R6#show rsvp session detail
Egress
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t1-Primary
Egress FSM state: Operational

Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25600, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 12.1.1.3, xe6
Path lifetime: 157 seconds (due in 143 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 19100 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
```

```
12.1.1.4/32 strict
Record route:
-------------------------------------------------------------
IP Address Label
-------------------------------------------------------------
10.10.1.1
11.1.1.2
12.1.1.3
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:
Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Egress
47.47.47.47
From: 40.40.40.40, LSPstate: Up, LSPname: t2-Primary
Egress FSM state: Operational
Setup priority: 7, Hold priority: 0
IGP-Shortcut: Disabled, LSP metric: 65
LSP Protection: None
Label in: 25601, Label out: -,
Tspec rate: 0, Fspec rate: 0
Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 40.40.40.40
Bind value: 0, Oper state: NA, Alloc mode: NA
Upstream: 15.1.1.3, xe5
Path lifetime: 157 seconds (due in 156 seconds)
Resv refresh: 30 seconds (RR enabled) (due in 30939 seconds)
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: Received Explicit Route Detail :
15.1.1.4/32 strict
Record route:
-------------------------------------------------------------
IP Address Label
-------------------------------------------------------------
13.1.1.1
14.1.1.2
15.1.1.3
<self>
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 1500
LSP Type: ELSP_CONFIG
CLASS DSCP_value EXP_value
Recorded Time : N/A
Current Error:

Code : None, Value : None
Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
R6#show mpls ilm-table
```

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```
Codes: > - installed ILM, * - selected ILM, p - stale ILM, ! - using backup
K - CLI ILM, T - MPLS-TP, s - Stitched ILM
S - SNMP, L - LDP, R - RSVP, C - CRLDP
B - BGP , K - CLI , V - LDP_VC, I - IGP_SHORTCUT
O - OSPF/OSPF6 SR, i - ISIS SR, k - SR CLI
P - SR Policy, U - unknown
LDP ilm-ecmp - disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-Intf/VRF Nexthop pri
LSP-Type
R> 47.47.47.47/32 1 25600 Nolabel N/A N/A 127.0.0.1 Yes ELSP_CONFIG
R> 47.47.47.47/32 2 25601 Nolabel N/A N/A 127.0.0.1 Yes ELSP_CONFIG
```

CHAPTER 4 RSVP Graceful Restart Configuration

Overview

The RSVP-TE graceful restart enables routers to maintain MPLS forwarding state when a link or node failure occurs. In a link failure, control communication is lost between two nodes, however, the nodes do not lose their control or forwarding state. RSVP Graceful restart (GR) is one of the fault-handling mechanism, that protects the forwarding state of the node during failure and helps to reinstate the previous state when the node has recovered.

Topology

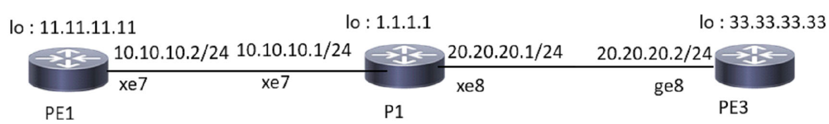

Figure 4-21: RSVP Graceful Restart

Configuration

PE1-NSM

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 11.11.11.11/32 secondary`	Set the IP address for the interface.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe7`	Enter interface mode.
`(config-if)#ip address 10.10.10.2/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface `xe7`.
`(config-if)#commit`	Commit the transaction.

PE1-RSVP-TE

`(config)#router rsvp`	Enter `Configure Router` mode.
`(config-router)#exit`	Exit `Router` mode.
`(config)#interface xe7`	Enter interface mode.
`(config-if)#enable-rsvp`	Enable RSVP message exchange on this interface.
`(config-if)#commit`	Commit the transaction.

PE1-OSPF

`#configure terminal`	Enter configure mode.
`(config)#router ospf 100`	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
`(config-router)#router-id 11.11.11.11`	Configure OSPF router-ID same as loopback interface IP address
`(config-router)#network 10.10.10.0/24 area 0`	Define the network (10.10.10.0/24) on which OSPF runs and associate the area ID (0).
`(config-router)#network 11.11.11.11/32 area 0`	Set the IP address of the loopback interface to 11.11.11.11/32.
`(config-router)#commit`	Commit the transaction.

P - NSM

`#configure terminal`	Enter configure mode.
`(config)#interface lo`	Enter interface mode.
`(config-if)#ip address 1.1.1.1/32 secondary`	Set the IP address for the interface.
`(config-if)#exit`	Enable label switching on interface lo.
`(config)#interface xe7`	Enter interface mode.
`(config-if)#ip address 10.10.10.1/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface xe7.
`(config-if)#exit`	Exit interface mode.
`(config)#interface xe8`	Enter interface mode.
`(config-if)#ip address 20.20.20.1/24`	Set the IP address for the interface.
`(config-if)#label-switching`	Enable label switching on interface xe7.
`(config-if)#commit`	Commit the transaction.

P - RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface xe7	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#exit	Exit interface mode.
(config)#interface xe8	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

P - OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 1.1.1.1	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 10.10.10.0/24 area 0	Define the first network (10.10.10.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 20.20.20.0/24 area 0	Define the second network (20.20.20.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 1.1.1.1/32 area 0	Set the IP address of the loopback interface to 1.1.1.1/32.
(config-router)#commit	Commit the transaction.

PE3 - NSM

#configure terminal	Enter configure mode.
(config)#interface lo	Enter interface mode.
(config-if)#ip address 33.33.33.33/32 secondary	Set the IP address for the interface.
(config-if)#exit	Exit interface mode.
(config)#interface ge8	Enter interface mode.
(config-if)#ip address 20.20.20.2/24	Set the IP address for the interface.
(config-if)#label-switching	Enable label switching on interface ge8.
(config-if)#commit	Commit the transaction.

PE3- RSVP-TE

(config)#router rsvp	Enter Configure Router mode.
(config-router)#exit	Exit Router mode.
(config)#interface ge8	Enter interface mode.
(config-if)#enable-rsvp	Enable RSVP message exchange on this interface.
(config-if)#commit	Commit the transaction.

PE3 - OSPF

#configure terminal	Enter configure mode.
(config)#router ospf 100	Configure the Routing process and specify the Process ID (100). The Process ID should be a unique positive integer identifying the routing process.
(config-router)#router-id 33.33.33.33	Configure OSPF router-ID same as loopback interface IP address
(config-router)#network 20.20.20.0/24 area 0	Define the network (20.20.20.0/24) on which OSPF runs and associate the area ID (0).
(config-router)#network 33.33.33.33/32 area 0	Set the IP address of the loopback interface to 33.33.33.33/32.
(config-router)#commit	Commit the transaction.

PE1 - RSVP-Path

#configure terminal	Enter configure mode.
(config)#rsvp-path PE1_to_PE3_via_P1 mpls	Create an RSVP Path and enter the Path mode.
(config-path)#10.10.10.1 strict	Configure this explicit route path as a strict hop.
(config-path)#20.20.20.2 strict	Configure this explicit route path as a strict hop.
(config-path)#exit	Exit Path mode.
#configure terminal	Enter configure mode.
(config)#rsvp-trunk PE1_to_PE3 ipv4	Create an RSVP trunk and enter the Trunk mode.
(config-trunk)#primary path PE1_to_PE3_via_P1	Configure the trunk to use defined path.
(config-trunk)#from 11.11.11.11	Specify ipv4 source point for the LSP.
(config-trunk)#to 33.33.33.33	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

PE3 - RSVP-Path

#configure terminal	Enter configure mode.
(config)#rsvp-path PE3_to_PE1_via_P1 mpls	Create an RSVP Path and enter the Path mode.
(config-path)#20.20.20.1 strict	Configure this explicit route path as a strict hop.
(config-path)#10.10.10.2 strict	Configure this explicit route path as a strict hop.
(config-path)#exit	Exit Path mode.
#configure terminal	Enter configure mode.
(config)#rsvp-trunk PE3_to_PE1 ipv4	Create an RSVP trunk and enter the Trunk mode.
(config-trunk)#primary path PE3_to_PE1_via_P1	Configure the trunk to use defined path.
(config-trunk)#from 33.33.33.33	Specify the ipv4 source point for LSP
(config-trunk)#to 11.11.11.11	Specify the IPv4 egress (destination point) for the LSP.
(config-trunk)#commit	Commit the transaction.

PE1 – RSVP-GR

#configure terminal	Enter configure mode.
(config)#router rsvp	nter the configuration router mode.
(config-router)#neighbor 10.10.10.1	Configure the neighbor ip address.
(config-router)#graceful-restart	Enable the rsvp-gr.
(config-router)#commit	Commit the transaction.

P1 – RSVP-GR

#configure terminal	Enter configure mode.
(config)#router rsvp	Enter the configuration router mode.
(config-router)#neighbor 10.10.10.2	Configure the neighbor ip address.
(config-router)#neighbor 20.20.20.2	Configure the neighbor ip address.
(config-router)#graceful-restart	Enable the rsvp-gr.
(config-router)#commit	Commit the transaction.

PE3 – RSVP-GR

`#configure terminal`	Enter configure mode.
`(config)#router rsvp`	Enter the router configuration mode.
`(config-router)#neighbor 20.20.20.1`	Configure the neighbor ip address.
`(config-router)#graceful-restart`	Enable the rsvp-gr.
`(config-router)#commit`	Commit the transaction.

Validation

Verify the RSVP graceful restart on PE1.

```
PE1#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 200000 msec
Advertised Recovery Time: 360000 msec
Sending Recovery Time: No
```

```
PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forc
ed to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Egress RSVP:
To             From           Tun-ID   LSP-ID   Type   LSPName           State   Uptime     Rt   Style  Labelin   Labelout
11.11.11.11    33.33.33.33    5001     2201     PRI    PE1_to_PE3 ipv4s   UP     00:54:57   1 1  SE        3          -

Total 5 displayed, Up 5, Down 0.
```

Verify after performing RSVP graceful restart on PE1

```
7038-PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled

Code     FEC                FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label    Out-Intf    ELC    Nexthop
   L>    1.1.1.1/32         3         4
                                      3         -           Yes   LSP_DEFAULT  3            xe7         No     10.10.10.1
R(t)> p 33.33.33.33/32      20        81        5001        Yes   LSP_DEFAULT  26881        xe7         Yes p  10.10.10.1
```

CHAPTER 5 RSVP Detour Over Ring Topology

Overview

In OcNOS, this feature allows the detour formation in the ring topology to enhance the routing experience. The detour formation is a local protection mechanism to reroute the data traffic when a failure or congestion occurs in the primary Label Switched Path (LSP). In Multiprotocol Label Switching (MPLS), the primary LSP is the default path through which the data travels from the source to the destination node.

Feature Characteristics

This feature allows detour to take the upstream path of protected LSP, allowing a detour based protection in a ring topology. The upstream path of the protected LSP is the section of the network that precedes the PLR node in the network. This feature works for both path and sender-template method of detour formation. For the inter-op solutions that do not support the sender-template method, use the path method of detour formation.

In the below diagram, the data traffic path highlighted in green dots is the primary LSP. The link shown with the red cross is locally protected at the Point of Local Repair (PLR) node. A PLR node is a network device that reacts and takes action when a link fails. For continued data traffic flow, detour occurs through the red dotted line. Detour in MPLS is an alternate path used when the primary LSP encounters disruption or congestion.

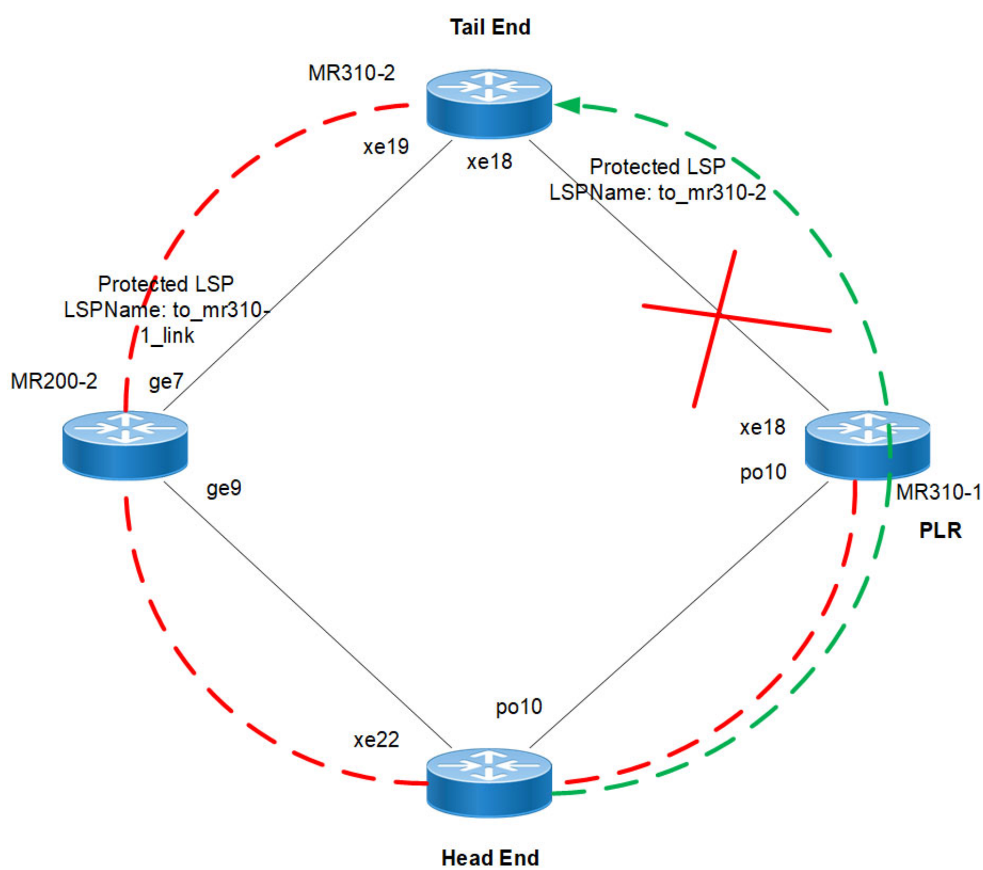

Figure 5-1: RSVP-TE FRR failover ring topology Feature Characteristics

Benefits

This feature helps detour the data traffic when there is a link or node failure, keeping the data traffic loss to a minimum (less than 50ms when BFD negotiated for fastest detection).

Prerequisite

Before the detour configuration in a ring topology, configure the RSVP tunnel with fast reroute protection of the one-to-one method.

For more information, refer to the Fast Reroute Configuration (one-to-one method) section of the RSVP-TE Configuration chapter in the *OcNOS Multi-Protocol Label Switching Guide*.

Configuration

This section shows the configuration procedure to create a detour in the ring topology.

Topology

Configure the primary LSP in the below ring topology from the head end to the tail end.

For example, consider PE1 as the head end and PE2 as the tail end, and the primary LSP is via R1, R2, and R3. In this case, first configure the Fast Reroute Configuration (one-to-one method) on the PE1 and PE2 and then configure the detour-allow-primary-upstream-path command in all the nodes. For example, if the link between R3 and PE2 is down, the detour follows via primary LSP to reach PE2.

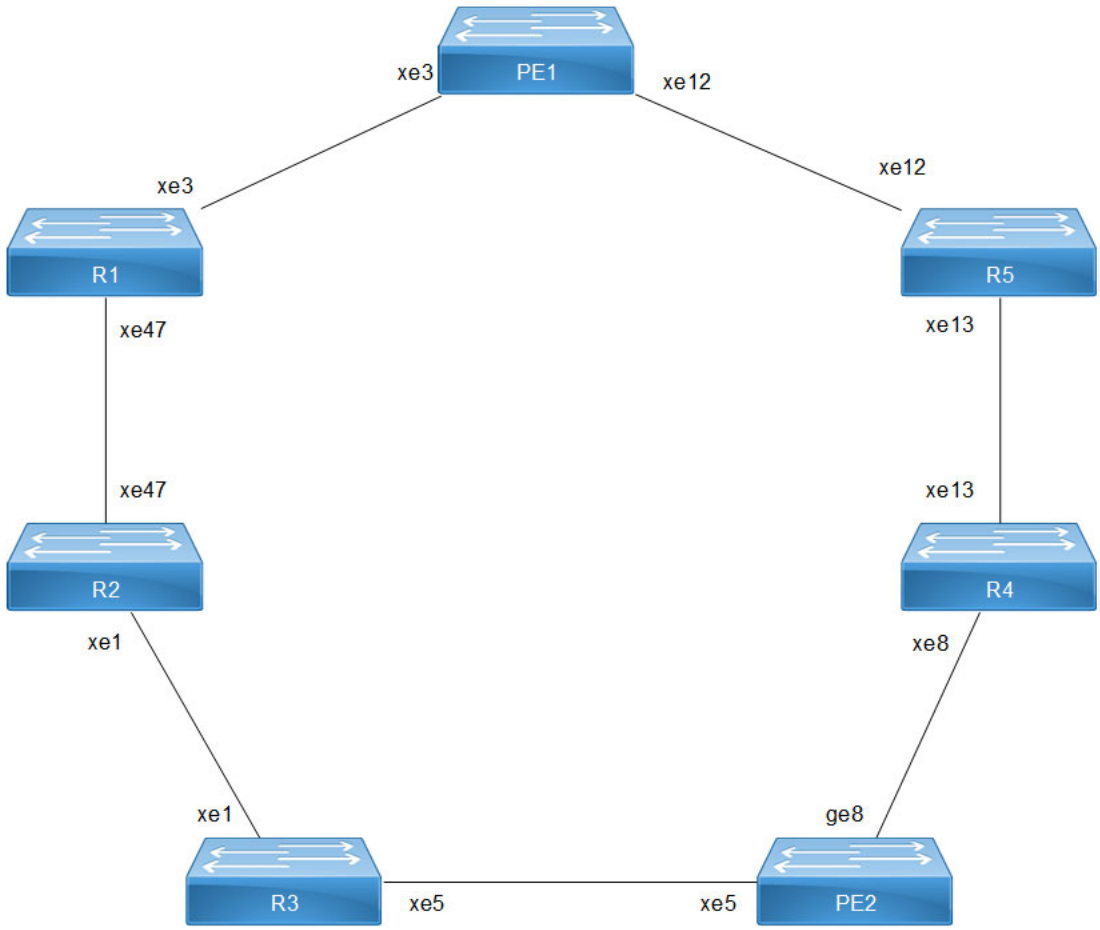

Figure 5-2: RSVP-TE FRR failover ring topology - 1:1 Detour

PE1 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

`PE1#configure terminal`	Enter configure mode.
`PE1(config)#interface xe3`	Enter interface mode `xe3`.
`PE1(config-if)#ip address 61.61.61.3/24`	Configure IPv4 address `61.61.61.3.24`.
`PE1(config-if)#label-switching`	Configure label switching on `xe3`.
`PE1(config-if)#enable-rsvp`	Enable RSVP on `xe3`.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config)#interface xe12`	Enter interface mode `xe12`.
`PE1(config-if)#ip address 58.58.58.2/24`	Configure IPv4 address `58.58.58.2/24`.
`PE1(config-if)#label-switching`	Configure label switching on `xe12`.
`PE1(config-if)#enable-rsvp`	Enable RSVP on `xe12`.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config)#interface lo`	Enter loopback interface mode.

`PE1(config-if)#ip address 26.26.26.26/32 secondary`	Configure IPv4 address `26.26.26.26/32`.
`PE1(config-if)#exit`	Exit interface mode.
`PE1(config)#router ospf 100`	Enter OSPF router mode.
`PE1(config-router)#ospf router-id 26.26.26.26`	Assign router ID `26.26.26.26` for OSPF.
`PE1(config-router)#network 26.26.26.26/32 area 0.0.0.0`	Define network `26.26.26.26/32` under router OSPF.
`PE1(config-router)#network 58.58.58.0/24 area 0.0.0.0`	Define network `58.58.58.0/24` under router OSPF.
`PE1(config-router)#network 61.61.61.0/24 area 0.0.0.0`	Define network `61.61.61.0/24` under router OSPF.
`PE1(config-router)#exit`	Exit router OSPF mode.
`PE1(config)#commit`	Commit the transaction.
`PE1(config)#exit`	Exit the configure mode.

PE1 - RSVP Configurations

This section shows:

1. The configuration of detour to take the upstream path of protected LSP.
2. The configuration of the primary LSP and attaching it to the RSVP trunk.
3. The configuration of the FRR.

`PE1#configure terminal`	Enter configure mode.
`PE1(config)#router rsvp`	Enable RSVP globally.
`PE1(config-router)#detour-allow-primary-upstream-path`	Configure this CLI to allow detour to take primary upstream path.
`PE1(config-router)#exit`	Exit router RSVP mode.
`PE1(config)#rsvp-path PE1-PE2-01 mpls`	Configure RSVP path PE1-PE2-01 and enter path mode.
`PE1(config-path)#61.61.61.2 strict`	Configure this explicit route path as a strict hop.
`PE1(config-path)#23.23.23.3 strict`	Configure this explicit route path as a strict hop.
`PE1(config-path)#41.41.41.3 strict`	Configure this explicit route path as a strict hop.
`PE1(config-path)#56.56.56.3 strict`	Configure this explicit route path as a strict hop.
`PE1(config-path)#rsvp-trunk TR-PE1-PE2-MP-01 ipv4`	Create an RSVP trunk TR-PE1-PE2-MP-01 and enter the trunk mode.
`PE1(config-trunk)#primary fast-reroute protection one-to-one`	Configure primary fast reroute protection.
`PE1(config-trunk)#primary fast-reroute node-protection`	Configure node protection.
`PE1(config-trunk)#primary path PE1-PE2-01`	Configure trunk PE1-PE2-01 to use as the primary LSP.
`PE1(config-trunk)#from 26.26.26.26`	Assign the source loopback address `26.26.26.26` to the RSVP trunk.
`PE1(config-trunk)#to 22.22.22.22`	Assign the destination loopback address `22.22.22.22` to the RSVP trunk.
`PE1(config-trunk)#exit`	Exit router RSVP trunk mode.

PE1(config)#commit	Commit the transaction.
PE1(config)#exit	Exit the configure mode.

R1 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

R1#configure terminal	Enter configure mode.
R1(config)#interface xe3	Enter interface mode xe3.
R1(config-if)#ip address 61.61.61.2/24	Configure IPv4 address 61.61.61.2/24.
R1(config-if)#label-switching	Configure label switching on xe3.
R1(config-if)#enable-rsvp	Enable RSVP on interface xe3.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface xe47	Enter interface mode xe47.
R1(config-if)#ip address 23.23.23.2/24	Configure IPv4 address 23.23.23.2/24.
R1(config-if)#label-switching	Configure label switching on xe47.
R1(config-if)#enable-rsvp	Enable RSVP on interface xe47.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface lo	Enter loopback interface mode.
R1(config-if)#ip address 24.24.24.24/32 secondary	Configure IPv4 address 24.24.24.24/32.
R1(config-if)#exit	Exit interface mode.
R1(config)#router ospf 100	Enter OSPF router mode.
R1(config-router)#ospf router-id 24.24.24.24	Assign router-id for OSPF.
R1(config-router)#network 23.23.23.0/24 area 0.0.0.0	Define network 23.23.23.0/24 under router OSPF.
R1(config-router)#network 24.24.24.24/32 area 0.0.0.0	Define network 24.24.24.24/32 under router OSPF.
R1(config-router)#network 61.61.61.0/24 area 0.0.0.0	Define network 61.61.61.0/24 under router OSPF.
R1(config-router)#exit	Exit router OSPF mode.
R1(config)#commit	Commit the transaction.
R1(config)#exit	Exit the configure mode.

R1 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

R1#configure terminal	Enter configure mode.
R1(config)#router rsvp	Enable RSVP globally.
R1(config-router)#detour-allow-primary-upstream-path	Configure this CLI to allow detour to take primary upstream path.
R1(config-router)#exit	Exit router RSVP mode.
R1(config)#commit	Commit the transaction.
R1(config)#exit	Exit the configure mode.

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R2 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

`R2#configure terminal`	Enter configure mode.
`R2(config)#interface xe1`	Enter interface mode `xe1`.
`R2(config-if)#ip address 41.41.41.2/24`	Configure IPv4 address `41.41.41.2/24`.
`R2(config-if)#label-switching`	Configure label switching on `xe1`.
`R2(config-if)#enable-rsvp`	Enable RSVP on `xe1`.
`R2(config-if)#exit`	Exit interface mode.
`R2(config)#interface xe47`	Enter interface mode `xe47`.
`R2(config-if)#ip address 23.23.23.3/24`	Configure IPv4 address `23.23.23.3/24`.
`R2(config-if)#label-switching`	Configure label switching on `xe47`.
`R2(config-if)#enable-rsvp`	Enable RSVP on `xe47`.
`R2(config-if)#exit`	Exit interface mode.
`R2(config)#interface lo`	Enter loopback interface mode.
`R2(config-if)#ip address 88.88.88.88/32 secondary`	Configure IPv4 address `88.88.88.88/32`.
`R2(config-if)#exit`	Exit interface mode.
`R2(config)#router ospf 100`	Enter OSPF router mode.
`R2(config-router)#ospf router-id 88.88.88.88`	Assign router-id `88.88.88.88` for OSPF.
`R2(config-router)#network 23.23.23.0/24 area 0.0.0.0`	Define network `23.23.23.0/24` under router OSPF.
`R2(config-router)#network 41.41.41.0/24 area 0.0.0.0`	Define network `41.41.41.0/24` under router OSPF.
`R2(config-router)#network 88.88.88.88/32 area 0.0.0.0`	Define network `88.88.88.88/32` under router OSPF.
`R2(config-router)#exit`	Exit router OSPF mode.
`R2(config)#commit`	Commit the transaction.
`R2(config)#exit`	Exit the configure mode.

R2 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

`R2#configure terminal`	Enter configure mode.
`R2(config)#router rsvp`	Enable RSVP globally.
`R2(config-router)#detour-allow-primary-upstream-path`	Configure this CLI to allow detour to take primary upstream path.
`R2(config-router)#exit`	Exit router RSVP mode.
`R2(config)#commit`	Commit the transaction.
`R2(config)#exit`	Exit the configure mode.

R3 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

`R3#configure terminal`	Enter configure mode.
`R3(config)#interface xe1`	Enter interface mode `xe1`.
`R3(config-if)#ip address 41.41.41.3/24`	Configure IPv4 address `41.41.41.3/24`.
`R3(config-if)#label-switching`	Configure label switching on `xe1`.
`R3(config-if)#enable-rsvp`	Enable RSVP on `xe1`.
`R3(config-if)#exit`	Exit interface mode.
`R3(config)#interface xe5`	Enter interface mode `xe5`.
`R3(config-if)#ip address 56.56.56.2/24`	Configure IPv4 address `56.56.56.2/24`.
`R3(config-if)#label-switching`	Configure label switching on `xe5`.
`R3(config-if)#enable-rsvp`	Enable RSVP on `xe5`.
`R3(config-if)#exit`	Exit interface mode.
`R3(config)#interface lo`	Enter loopback interface mode.
`R3(config-if)#ip address 99.99.99.99/32 secondary`	Configure IPv4 address `99.99.99.99/32`.
`R3(config-if)#exit`	Exit interface mode.
`R3(config)#router ospf 100`	Enter OSPF router mode.
`R3(config-router)#ospf router-id 99.99.99.99`	Assign router-id for OSPF.
`R3(config-router)#network 41.41.41.0/24 area 0.0.0.0`	Define network `41.41.41.0/24` under router OSPF.
`R3(config-router)#network 56.56.56.0/24 area 0.0.0.0`	Define network `56.56.56.0/24` under router OSPF.
`R3(config-router)#network 99.99.99.99/32 area 0.0.0.0`	Define network `99.99.99.99/32` under router OSPF.
`R3(config-router)#exit`	Exit router OSPF mode.
`R3(config)#commit`	Commit the transaction.
`R3(config)#exit`	Exit the configure mode.

R3 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

`R3#configure terminal`	Enter configure mode.
`R3(config)#router rsvp`	Enable RSVP globally.
`R3(config-router)#detour-allow-primary-upstream-path`	Configure this CLI to allow detour to take primary upstream path.
`R3(config-router)#exit`	Exit router RSVP mode.
`R3(config)#commit`	Commit the transaction.
`R3(config)#exit`	Exit the configure mode.

R5 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

`R5#configure terminal`	Enter configure mode.
`R5(config)#interface xe1`	Enter interface mode `58.58.58.3/24`.
`R5(config-if)#ip address 58.58.58.3/24`	Configure IPv4 address.
`R5(config-if)#label-switching`	Configure label switching on `xe1`.
`R5(config-if)#enable-rsvp`	Enable RSVP on `xe1`.
`R5(config-if)#exit`	Exit interface mode.
`R5(config)#interface xe13`	Enter interface mode `xe13`.
`R5(config-if)#ip address 54.54.54.4/24`	Configure IPv4 address `54.54.54.4/24`.
`R5(config-if)#label-switching`	Configure label switching on `xe13`.
`R5(config-if)#enable-rsvp`	Enable RSVP on `xe13`.
`R5(config-if)#exit`	Exit interface mode.
`R5(config)#interface lo`	Enter loopback interface mode.
`R5(config-if)#ip address 17.17.17.17/32 secondary`	Configure IPv4 address `17.17.17.17/32`.
`R5(config-if)#exit`	Exit interface mode.
`R5(config)#router ospf 100`	Enter OSPF router mode.
`R5(config-router)#ospf router-id 17.17.17.17`	Assign router-id for OSPF.
`R5(config-router)#network 17.17.17.17/32 area 0.0.0.0`	Define network `17.17.17.17/32` under router OSPF.
`R5(config-router)#network 54.54.54.0/24 area 0.0.0.0`	Define network `54.54.54.0/24` under router OSPF.
`R5(config-router)#network 58.58.58.0/24 area 0.0.0.0`	Define network `58.58.58.0/24` under router OSPF.
`R5(config-router)#exit`	Exit router OSPF mode.
`R5(config)#commit`	Commit the transaction.
`R5(config)#exit`	Exit the configure mode.

R5 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

`R5#configure terminal`	Enter configure mode.
`R5(config)#router rsvp`	Enable RSVP globally.
`R5(config-router)#detour-allow-primary-upstream-path`	Configure this CLI to allow detour to take primary upstream path
`R5(config-router)#exit`	Exit router RSVP mode
`R5(config)#commit`	Commit the transaction.
`R5(config)#exit`	Exit the configure mode.

R4 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

`R4#configure terminal`	Enter configure mode.
`R4(config)#interface xe13`	Enter interface mode `xe13`.
`R4(config-if)#ip address 54.54.54.3/24`	Configure IPv4 address `54.54.54.3/24`.
`R4(config-if)#label-switching`	Configure label switching on `xe13`.
`R4(config-if)#enable-rsvp`	Enable RSVP on interface `xe13`.
`R4(config-if)#exit`	Exit interface mode.
`R4(config)#interface xe8`	Enter interface mode `xe8`.
`R4(config-if)#ip address 62.62.62.3/24`	Configure IPv4 address `62.62.62.3/24`.
`R4(config-if)#label-switching`	Configure label switching on `xe8`.
`R4(config-if)#enable-rsvp`	Enable RSVP on `xe8`.
`R4(config-if)#exit`	Exit interface mode.
`R4(config)#interface lo`	Enter loopback interface mode.
`R4(config-if)#ip address 48.48.48.48/32 secondary`	Configure IPv4 address `48.48.48.48/32`.
`R4(config-if)#exit`	Exit interface mode.
`R4(config)#router ospf 100`	Enter OSPF router mode.
`R4(config-router)#ospf router-id 48.48.48.48`	Assign router-id for OSPF.
`R4(config-router)#network 48.48.48.48/32 area 0.0.0.0`	Define network `48.48.48.48/32` under router OSPF.
`R4(config-router)#network 54.54.54.0/24 area 0.0.0.0`	Define network `54.54.54.0/24` under router OSPF.
`R4(config-router)#network 62.62.62.0/24 area 0.0.0.0`	Define network 62.62.62.0/24 under router OSPF.
`R4(config-router)#exit`	Exit router OSPF mode.
`R4(config)#commit`	Commit the transaction.
`R4(config)#exit`	Exit the configure mode.

R4 - RSVP Configurations

This section shows how to configure the detour to take the upstream path of protected LSP.

`R4#configure terminal`	Enter configure mode.
`R4(config)#router rsvp`	Enable RSVP globally.
`R4(config-router)#detour-allow-primary-upstream-path`	Configure this CLI to allow detour to take primary upstream path.
`R4(config-router)#exit`	Exit router RSVP mode.
`R4(config)#commit`	Commit the transaction.
`R4(config)#exit`	Exit the configure mode.

PE2 - OSPF Configurations

This section shows how to configure the Open Shortest Path First (OSPF) as Interior Gateway Protocol (IGP).

PE2#configure terminal	Enter configure mode.
PE2(config)#interface xe5	Enter interface mode xe5.
PE2(config-if)#ip address 56.56.56.3/24	Configure IPv4 address 56.56.56.3/24.
PE2(config-if)#label-switching	Configure label switching on xe5.
PE2(config-if)#enable-rsvp	Enable RSVP on xe5.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface ge8	Enter interface mode ge8.
PE2(config-if)#ip address 62.62.62.2/24	Configure IPv4 address 62.62.62.2/24.
PE2(config-if)#label-switching	Configure label switching on ge8.
PE2(config-if)#enable-rsvp	Enable RSVP on ge8.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface lo	Enter loopback interface mode.
PE2(config-if)#ip address 22.22.22.22/32 secondary	Configure IPv4 address 22.22.22.22/32.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router ospf 100	Enter OSPF router mode.
PE2(config-router)#ospf router-id 22.22.22.22	Assign router-id for OSPF.
PE2(config-router)#network 22.22.22.22/32 area 0.0.0.0	Define network 22.22.22.22/32 under router OSPF.
PE2(config-router)#network 56.56.56.0/24 area 0.0.0.0	Define network 56.56.56.0/24 under router OSPF.
PE2(config-router)#network 62.62.62.0/24 area 0.0.0.0	Define network 62.62.62.0/24 under router OSPF.
PE2(config-router)#exit	Exit router OSPF mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#exit	Exit the configure mode.

PE2 - RSVP Configurations

This section shows:

1. The configuration of detour to take the upstream path of protected LSP.
2. The configuration of the primary LSP and attaching it to the RSVP trunk.
3. The configuration of the FRR.

PE2#configure terminal	Enter configure mode.
PE2(config)#router rsvp	Enable RSVP globally.
PE2(config-router)#detour-allow-primary-upstream-path	Configure this CLI to allow detour to take primary upstream path.
PE2(config-router)#exit	Exit router RSVP mode.
PE2(config)#rsvp-path PE2-PE1-01 mpls	Configure RSVP path PE2-PE1-01 and enter path mode.
PE2(config-path)#56.56.56.2 strict	Configure this explicit route path as a strict hop.
PE2(config-path)#41.41.41.2 strict	Configure this explicit route path as a strict hop.

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PE2(config-path)#23.23.23.2 strict	Configure this explicit route path as a strict hop.
PE2(config-path)#61.61.61.3 strict	Configure this explicit route path as a strict hop.
PE2(config-router)#exit	Exit path mode.
PE2(config-path)#rsvp-trunk TR-PE2-PE1-MP-01 ipv4	Create an RSVP trunk TR-PE2-PE1-MP-01 and enter the Trunk mode.
PE2(config-trunk)#primary fast-reroute protection one-to-one	Configure primary fast-reroute protection.
PE2(config-trunk)#primary fast-reroute node-protection	Configure node protection.
PE2(config-trunk)#primary path PE2-PE1-01	Configure trunk PE2-PE1-01 to use as the primary LSP.
PE2(config-trunk)#from 22.22.22.22	Assign the source loopback address 22.22.22.22 to the RSVP trunk.
PE2(config-trunk)#to 26.26.26.26	Assign the destination loopback address 26.26.26.26 to the RSVP trunk.
PE2(config-trunk)#exit	Exit router RSVP trunk mode.
PE2(config)#commit	Commit the transaction.
PE2(config)#exit	Exit the configure mode.

Validation

PE1

Below is the validation output of RSVP LSPs from PE1 to PE2 via R1>R2>R3:

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     26.26.26.26     5001     2205     PRI    TR-PE1-PE2-MP-01-Primary        UP    02:12:32  1 1 SE     -
52480
22.22.22.22     58.58.58.2      5001     2205     DTR    TR-PE1-PE2-MP-01-Detour         UP    00:34:04  1 2 SE     -
25600
Total 2 displayed, Up 2, Down 0.

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     61.61.61.2      5001     2205     PRI    TR-PE1-PE2-MP-01-Detour         UP    00:33:19  1 2 SE     25602
25600
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
26.26.26.26     22.22.22.22     5001     2205     PRI    TR-PE2-PE1-MP-01-Primary        UP    02:12:27  1 1 SE     25601    -
26.26.26.26     62.62.62.2      5001     2205     PRI    TR-PE2-PE1-MP-01-Detour         UP    02:09:08  1 1 SE     25600    -
Total 2 displayed, Up 2, Down 0.
```

Below is the validation output of RSVP ping and trace from PE1 to PE2:

```
#ping mpls rsvp egress 22.22.22.22 detail
Sending 5 MPLS Echos to 22.22.22.22, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
```

```
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

! seq_num = 1 56.56.56.3 0.91 ms
! seq_num = 2 56.56.56.3 0.54 ms
! seq_num = 3 56.56.56.3 0.48 ms
! seq_num = 4 56.56.56.3 0.47 ms
! seq_num = 5 56.56.56.3 0.50 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.47/0.69/0.91
PE1#
#trace mpls rsvp egress 22.22.22.22 detail
Tracing MPLS Label Switched Path to 22.22.22.22, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

  0 61.61.61.3 [Labels:  52480]
R 1 61.61.61.2 [Labels:  25600] 0.71 ms
R 2 23.23.23.3 [Labels:  25600] 0.83 ms
R 3 41.41.41.3 [Labels:  25600] 0.88 ms
! 4 56.56.56.3 0.69 ms
```

Below are the outputs from transit nodes R1, R2 and R3 for primary LSP configured:

R1

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     61.61.61.2      5001     2205     DTR    TR-PE1-PE2-MP-01-Detour         UP    00:38:43  1 2 SE     -
25602
26.26.26.26     23.23.23.2      5001     2205     DTR    TR-PE2-PE1-MP-01-Detour         UP    00:38:44  1 1 SE     -
25603
Total 2 displayed, Up 2, Down 0.

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     26.26.26.26     5001     2205     PRI    TR-PE1-PE2-MP-01-Primary        UP    02:17:55  1 1 SE     52480
25600
22.22.22.22     23.23.23.3      5001     2205     PRI    TR-PE1-PE2-MP-01-Detour         UP    00:37:58  1 2 SE     52482
25602
26.26.26.26     22.22.22.22     5001     2205     PRI    TR-PE2-PE1-MP-01-Primary        UP    02:17:50  1 1 SE     52481
25601
Total 3 displayed, Up 3, Down 0.
```

R2

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
```

```
To              From            Tun-ID   LSP-ID   Type   LSPName                        State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     23.23.23.3      5001     2205     DTR    TR-PE1-PE2-MP-01-Detour        UP    00:38:07  1 2 SE     -
52482
26.26.26.26     41.41.41.2      5001     2205     DTR    TR-PE2-PE1-MP-01-Detour        UP    00:39:00  1 2 SE     -
25602
Total 2 displayed, Up 2, Down 0.

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                        State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     26.26.26.26     5001     2205     PRI    TR-PE1-PE2-MP-01-Primary       UP    02:18:05  1 1 SE     25600
25600
22.22.22.22     41.41.41.3      5001     2205     PRI    TR-PE1-PE2-MP-01-Detour        UP    00:37:28  1 2 SE     25602
52482
26.26.26.26     22.22.22.22     5001     2205     PRI    TR-PE2-PE1-MP-01-Primary       UP    02:18:00  1 1 SE     25601
52481
26.26.26.26     23.23.23.2      5001     2205     PRI    TR-PE2-PE1-MP-01-Detour        UP    00:38:53  1 2 SE     25603
25602
Total 4 displayed, Up 4, Down 0.
```

R3

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                        State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     41.41.41.3      5001     2205     DTR    TR-PE1-PE2-MP-01-Detour        UP    00:37:31  1 1 SE     -
25602
26.26.26.26     56.56.56.2      5001     2205     DTR    TR-PE2-PE1-MP-01-Detour        UP    00:39:23  1 2 SE     -
25602
Total 2 displayed, Up 2, Down 0.

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                        State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     26.26.26.26     5001     2205     PRI    TR-PE1-PE2-MP-01-Primary       UP    02:18:08  1 1 SE     25600
25600
26.26.26.26     22.22.22.22     5001     2205     PRI    TR-PE2-PE1-MP-01-Primary       UP    02:18:02  1 1 SE     25601
25601
26.26.26.26     41.41.41.2      5001     2205     PRI    TR-PE2-PE1-MP-01-Detour        UP    00:39:03  1 2 SE     25602
25602
Total 3 displayed, Up 3, Down 0.
```

Below are the outputs from transit nodes R4 and R5 for Detour LSPs formation:

From R4

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                        State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     58.58.58.2      5001     2205     PRI    TR-PE1-PE2-MP-01-Detour        UP    02:14:52  1 1 SE     25600
25601
26.26.26.26     62.62.62.2      5001     2205     PRI    TR-PE2-PE1-MP-01-Detour        UP    00:39:49  1 1 SE     25601
25601
Total 2 displayed, Up 2, Down 0.
```

From R5

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Transit RSVP:
```

```
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     58.58.58.2      5001     2205     PRI    TR-PE1-PE2-MP-01-Detour         UP    00:39:45  1 1 SE     25600
25600
26.26.26.26     62.62.62.2      5001     2205     PRI    TR-PE2-PE1-MP-01-Detour         UP    02:14:48  1 1 SE     25601
25600
Total 2 displayed, Up 2, Down 0.
```

Now, shutting down one of the interfaces on Primary LSP path and check RSVP tunnel outputs on PE1 and PE2

Shutdown interface xe47 connected between R1 and R2:

`#configure terminal`	Enter Configure mode.
`(config)#interface xe47`	Enter interface mode.
`(config-router)#shutdown`	Administratively bring the interface down.
`(config-router)#exit`	Exit router RSVP mode

Below is the validation output of RSVP LSPs from PE1 to PE2 after admin shutting one of the interfaces on primary LSP path:

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     26.26.26.26     5001     2205     PRI    TR-PE1-PE2-MP-01-Primary        UP*   02:32:40  1 1 SE     -
52480
22.22.22.22     26.26.26.26     5001     2201     PRI    TR-PE1-PE2-MP-01-Primary        DN    N/A       0 0 SE     -         -
22.22.22.22     58.58.58.2      5001     2205     DTR    TR-PE1-PE2-MP-01-Detour         UP    00:54:12  1 2 SE     -
25600
Total 3 displayed, Up 2, Down 1.

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     61.61.61.2      5001     2205     PRI    TR-PE1-PE2-MP-01-Detour         UP    00:53:27  1 2 SE     25602
25600
Total 1 displayed, Up 1, Down 0.
```

Below is the validation output of RSVP ping and trace from PE1 to PE2 after shutting one of the interfaces on primary LSP path:

```
Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
26.26.26.26     62.62.62.2      5001     2205     PRI    TR-PE2-PE1-MP-01-Detour         UP    02:29:16  1 1 SE     25600    -
Total 1 displayed, Up 1, Down 0.

#ping mpls rsvp egress 22.22.22.22 detail
Sending 5 MPLS Echos to 22.22.22.22, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

! seq_num = 1 62.62.62.2 0.69 ms
! seq_num = 2 62.62.62.2 0.54 ms
! seq_num = 3 62.62.62.2 0.56 ms
```

```
! seq_num = 4 62.62.62.2 0.49 ms
! seq_num = 5 62.62.62.2 0.51 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.49/0.59/0.69
#trace mpls rsvp egress 22.22.22.22 detail
Tracing MPLS Label Switched Path to 22.22.22.22, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

  0 61.61.61.3 [Labels:  52480]
R 1 61.61.61.2 [Labels:  25602] 0.72 ms
R 2 61.61.61.3 [Labels:  25600] 0.67 ms
R 3 58.58.58.3 [Labels:  25600] 0.80 ms
R 4 54.54.54.3 [Labels:  25601] 0.80 ms
! 5 62.62.62.2 0.50 ms
```

Below is the validation output of RSVP LSPs from PE2 to PE1 after admin shutting one of the interfaces on primary LSP path:

```
#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
26.26.26.26     22.22.22.22     5001     2205     PRI    TR-PE2-PE1-MP-01-Primary        UP*   02:36:19  1 1 SE     -
25601
26.26.26.26     22.22.22.22     5001     2201     PRI    TR-PE2-PE1-MP-01-Primary        DN    N/A       0 0 SE     -        -
26.26.26.26     62.62.62.2      5001     2205     DTR    TR-PE2-PE1-MP-01-Detour         UP    00:57:57  1 2 SE     -
25601
Total 3 displayed, Up 2, Down 1.

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
26.26.26.26     56.56.56.2      5001     2205     PRI    TR-PE2-PE1-MP-01-Detour         UP    00:57:40  1 2 SE     25602
25601
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName                         State Uptime    Rt  Style  Labelin
Labelout
22.22.22.22     58.58.58.2      5001     2205     PRI    TR-PE1-PE2-MP-01-Detour         UP    02:33:00  1 1 SE     25601    -
Total 1 displayed, Up 1, Down 0.
```

Below is the validation output of RSVP ping and trace from PE2 to PE1 after shutting one of the interfaces on primary LSP path:

```
#ping mpls rsvp egress 26.26.26.26 detail
Sending 5 MPLS Echos to 26.26.26.26, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort
```

```
! seq_num = 1 58.58.58.2 0.80 ms
! seq_num = 2 58.58.58.2 0.59 ms
! seq_num = 3 58.58.58.2 0.47 ms
! seq_num = 4 58.58.58.2 0.49 ms
! seq_num = 5 58.58.58.2 0.54 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.47/0.63/0.80
#trace mpls rsvp egress 26.26.26.26 detail
Tracing MPLS Label Switched Path to 26.26.26.26, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '.' - timeout,
'x' - Retcode 0, 'M' - Malformed Request, 'm' - Errored TLV,
'N' - LBL Mapping Err, 'D' - DS Mismatch,
'U' - Unknown Interface, 'R' - Transit (LBL Switched),
'B' - IP Forwarded, 'F' No FEC Found, 'f' - FEC Mismatch,
'P' - Protocol Error, 'X' - Unknown code,
'Z' - Reverse FEC Validation Failed

 Type 'Ctrl+C' to abort

  0 56.56.56.3 [Labels:  25601]
R 1 56.56.56.2 [Labels:  25601] 1.01 ms
R 2 41.41.41.2 [Labels:  25602] 0.95 ms
R 3 41.41.41.3 [Labels:  25602] 0.62 ms
R 4 56.56.56.3 [Labels:  25601] 0.79 ms
R 5 62.62.62.3 [Labels:  25601] 0.67 ms
R 6 54.54.54.4 [Labels:  25600] 0.57 ms
! 7 58.58.58.2 0.50 ms
```

Implementation Examples

To implement detour based protection in a ring topology, use the command detour-allow-primary-upstream-path that allows the detour formation to consider the upstream path of protected LSP. This is only applicable in ring topology.

New CLI Commands

detour-allow-primary-upstream-path

Use this command to ensure detour formation to consider the upstream path of protected LSPs. This is a deviation to RFC 4090 section 6.2 recommendation (https://datatracker.ietf.org/doc/html/rfc4090). This command is intended to be used in special cases where detour protection is required on ring topology if no alternate path is available.

Use the no parameter with this command to bypass the upstream path to the protected LSP when choosing a detour path.

Note: This command is intended to be used in ring topology if detour support is required at the cost of resource and link bandwidth. This command is not recommended to be configured otherwise.

Command Syntax

```
detour-allow-primary-upstream-path
no detour-allow-primary-upstream-path
```

Parameters

None

Default

By default, detour formation excludes the protected LSP upstream path as per RFC 4090 section 6.2 recommendations.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#detour-allow-primary-upstream-path
(config-router)#commit
(config-router)#no detour-allow-primary-upstream-path
(config-router)#commit
```

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Acronym	Description
FRR	Fast Reroute
LSP	Label Switched Path
OSPF	Open Shortest Path First
PLR	Point of Local Repair

Glossary

The following provides definitions for key terms used throughout this document:

Detour formation in the ring topology	The detour formation in the ring topology is a mechanism to reroute the data traffic over the backup path when a failure or congestion occurs in the primary Label Switched Path (LSP).
PLR node	A PLR node is a network device that reacts and takes action when a link fails.
Primary LSP	The primary LSP is the default path of the forwarding data packets from the source device to the destination device.
Protected LSP	A protected LSP is a primary LSP with a backup path in an MPLS network. When there is an issue or a failure in the primary LSP, the traffic is rerouted through the backup path, protecting the primary LSP.

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RSVP Tunnel	RSVP tunnels are logical paths through which data traffic traverses in an IP network.
Upstream path of the protected LSP	The upstream path of the protected LSP is the section of the network that precedes the PLR node in the network.

CHAPTER 6 RSVP-TE Dynamic Facility Backup LSP (RSVP Auto Bypass)

Overview

Resource Reservation Protocol (RSVP) auto bypass is a subset of the Facility Backup feature, designed to enhance fast-reroute protection. The facility backup feature operates by establishing bypass tunnels for protected sessions at each PLR node, serving as a local safeguard for sessions on every Point of Local Repair (PLR). Configuring bypass tunnels manually on each PLR, particularly in larger topologies, presented challenges in configuration management. The RSVP auto bypass functionality ensures to dynamically create bypass tunnels when feature enabled in PLR nodes and the sessions come up in PLR requesting facility backup protection.

Feature Characteristics

The RSVP auto bypass operates in conjunction with manual bypass tunnels, and if both manual and auto bypass offer the same level of protection as requested, the manual bypass takes precedence. Auto bypass tunnels, which do not serve any session, have a finite lifetime and are deleted if they remain unused.

Benefits

RSVP auto bypass contributes to a more automated, efficient, and manageable facility backup protection mechanism in RSVP-enabled networks.

Prerequisites

Ensure the following prerequisites are met before configuring RSVP Auto Bypass functionality:

Define Interfaces and Loopback Addresses

Configure Layer 2 interfaces, such as port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification, and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
 ip address 127.0.0.1/8
 ip address 135.1.1.27/32 secondary
 ipv6 address ::1/128
!
interface po6
 ip address 1.1.2.2/30
!
interface xe6
 channel-group 6 mode active
!
```

Configure IGP for Dynamic Routing

Enable ISIS to facilitate dynamic routing on all nodes within the network. Define ISIS router instances to match loopback IP addresses and add network segments to ISIS areas for proper route distribution. Set up neighbor relationships using loopback IP addresses, ensuring efficient route advertisement and convergence for optimal network performance.

ISIS Configuration

```
!
router isis 1
 is-type level-2-only
 metric-style wide
 mpls traffic-eng router-id 135.1.1.27
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 fast-reroute ti-lfa level-2 proto ipv4
 net 49.0000.0000.0027.00
 passive-interface lo
!
interface po6
 isis network point-to-point
 ip router isis 1
!
```

OSPF Configuration

```
!
router ospf 100
 ospf router-id 135.1.1.27
 network 135.1.1.27/32 area 0.0.0.0
 network 1.1.5.1/24 area 0.0.0.0
 network 1.1.1.1/24 area 0.0.0.0
!
```

Configure RSVP for Efficient Network Operation

Enable Resource Reservation Protocol (RSVP) on all nodes to optimize traffic routing and quality of service. RSVP reserves network resources along specified paths to enhance network performance and reliability.

```
!
router rsvp
!
interface xe1
 label-switching
 enable-rsvp
!
```

Configure the RSVP Primary Path and Trunk

Establish a trunk on edge routers participating in label-switching using defined path.

```
!
rsvp-path PE1-PE4-1 mpls
```

```
  1.1.1.2 strict
  1.1.2.1 strict
  1.1.6.1 strict
 !
 rsvp-trunk PE1-PE4-1 ipv4
  primary fast-reroute protection facility
  primary fast-reroute node-protection
  primary path PE1-PE4-1
  from 135.1.1.27
  to 135.1.1.44
 !
```

Configuration for RSVP Auto Bypass

This section shows the configuration of the various nodes within the topology to set up a RSVP-Auto bypass tunnels.

Topology

The sample topology includes Edge Nodes (PE1, PE2) and core Nodes (P1, P3 and P4). As per sample configurations, Primary path is defined via PE1-P1-P3-PE2 using strict hops and auto bypass tunnel creation is formed on PE1.

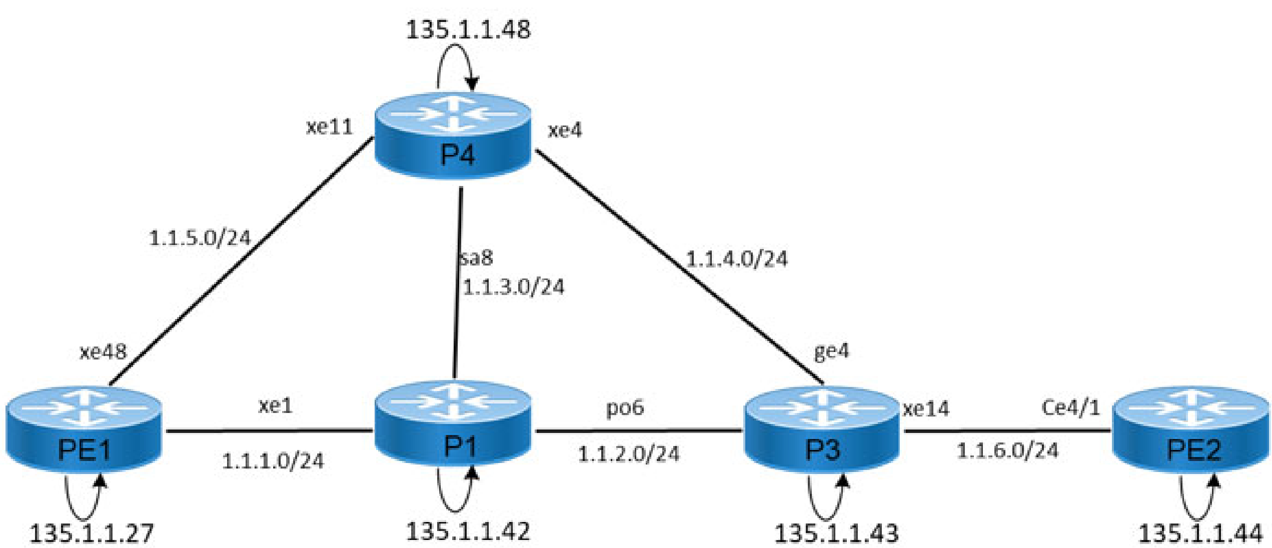

Figure 6-3: RSVP-Auto Bypass Configuration

Before configuring RSVP-Auto bypass tunnles, meet all Prerequisites for the following nodes:

- Edge nodes: PE1 and PE2
- Core nodes: P1, P3, and P4

Auto bypass feature helps in automatically forming bypass tunnels and protecting the facility backup protection requested tunnels.

Configuring RSVP Auto Bypass

Configure RSVP Auto bypass tunnels on PE1 router as follows:

1. Configure auto-bypass under router rsvp.
```
(config)#router rsvp
(config-router)# auto-bypass
```
2. Enable Auto bypass globally.
```
(config-auto-bypass)#  enable
```
3. Modify protection capability attribute for best-effort type bypasses.
```
(config-auto-bypass)# attributes best-effort
(config-auto-bypass-attr)#protection-capability node
```
4. Modify other auto bypass attributes for best-effort type bypasses.

   Note: Auto bypass re-optimization uses the global command to set the re-optimization timer.
```
(config-auto-bypass-attr)#   reoptimize
```
5. Configure inactivity timer globally for automatically created bypass tunnels.

   Note: The default value for the inactivity-timer is 60 minutes. The minimum timer is 1 and maximum timer is 240.
```
(config-auto-bypass)#  inactivity-timer 5
```

Configure RSVP Auto bypass tunnels on P1, P3, P4, PE2 router as follows:

1. Configure auto-bypass under router rsvp.
```
(config)#router rsvp
(config-router)# auto-bypass
```
2. Enable Auto bypass globally.
```
(config-auto-bypass)#  enable
```
3. Modify protection capability attribute for best-effort type bypasses.
```
(config-auto-bypass)# attributes best-effort
(config-auto-bypass-attr)#protection-capability link
```
4. Modify other auto bypass attributes for best-effort type bypasses.

   Note: Auto bypass re-optimization shall use the global command to set the re-optimization timer.
```
(config-auto-bypass-attr)#   reoptimize
```
5. Configure inactivity timer globally for automatically created bypass tunnels.

   Note: The default value for the inactivity-timer is 60 minutes. The minimum timer is 1 and maximum timer is 240.
```
(config-auto-bypass)#  inactivity-timer 5
```

Snippet configuration on PE1 router is as follows:

```
!
router rsvp
 auto-bypass
  attributes best-effort
   protection-capability node
   reoptimize
   exit
  inactivity-timer 5
  enable
  exit
!
```

Snippet configuration on P1, P3, and P4 router is as follows:

```
#show running-config
!
router rsvp
  auto-bypass
  attributes best-effort
   protection-capability link
   reoptimize
   exit
  enable
  exit
!
```

Validation

Verify all sessions including auto bypass sessions summary information:

Bypass name will have a character B or D. BL for Link protection and BN is for Node protection.

```
PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.43      135.1.1.27      5001     2203     BPS   BN-135.1.1.42-135.1.1.43-Bypass
UP    00:02:46  1 1 SE     -        25604
135.1.1.44     135.1.1.27     5002    2202    PRI    PE1-PE4-1-Primary            UP
00:13:21  1 1 SE     -        25600
Total 2 displayed, Up 2, Down 0.

Transit RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
```

```
135.1.1.43      135.1.1.42      5001     2201     PRI    BL-1.1.2.1-135.1.1.43-Bypass
UP    00:10:11  1 1 SE     25601    25600
135.1.1.42      135.1.1.43      5002     2202     PRI    BL-1.1.2.2-135.1.1.42-Bypass
UP    00:10:00  1 1 SE     25602    3
Total 2 displayed, Up 2, Down 0.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.27     135.1.1.44     5001    2201    PRI    Pe4-Pe1-Primary              UP
00:13:15  1 1 SE     25600    -
135.1.1.27      135.1.1.42      5002     2202     PRI    BL-1.1.1.1-135.1.1.27-Bypass
UP    00:10:00  1 1 SE     3        -


PE2#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.27     135.1.1.44     5001    2201    PRI    Pe4-Pe1-Primary              UP
00:16:18  1 1 SE     -        25601
135.1.1.43      135.1.1.44      5002     2202     BPS    BL-1.1.6.2-135.1.1.43-Bypass
UP    N/A       0 0 SE     -        -
Total 2 displayed, Up 1, Down 1.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.44     135.1.1.27     5002    2202    PRI    PE1-PE4-1-Primary            UP
00:16:24  1 1 SE     25600    -
Total 1 displayed, Up 1, Down 0.
```

Verify all sessions including auto bypass sessions detailed information:

```
PE1#show rsvp session detail
Egress
135.1.1.27
  From: 135.1.1.44, LSPstate: Up, LSPname: Pe4-Pe1-Primary
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Link
  Fast-Reroute Hop limit: 255
```

```
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Label in:    25600,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 135.1.1.44
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 1.1.1.2, xe1
  Path lifetime: 157 seconds (due in 140 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 24093 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups: none
  Received Explicit Route Detail :
   1.1.1.1/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   1.1.6.1           25601
   1.1.2.1           25601
   1.1.1.2           25600
   <self>
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
Ingress (Bypass)
135.1.1.43
  From: 135.1.1.27, LSPstate: Up, LSPname: BN-135.1.1.42-135.1.1.43-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 11ms
  Setup priority: 7, Hold priority: 0, HOP limit: 255
  Auto-bypass Info: Exclude-Node 135.1.1.42, Egress 135.1.1.43, Cspf ISIS
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Enabled, Re-Optimization Timer: 1 minutes, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 20
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    25604,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2203, Ext-Tunnel Id: 135.1.1.27
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.5.2, xe48
  Path refresh: 30 seconds (RR enabled) (due in 29821 seconds)
```

```
  Resv lifetime: 157 seconds (due in 147 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: none
  Exclude Node: 135.1.1.42
  Session Explicit Route Detail :
   1.1.5.2/32 strict
   1.1.4.1/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   <self>
   1.1.5.2
   1.1.4.1
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
  Total LSP protected : 1, Bandwidth in use : 0
Transit
135.1.1.43
  From: 135.1.1.42, LSPstate: Up, LSPname: BL-1.1.2.1-135.1.1.43-Bypass
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    25601,  Label out:    25600,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 135.1.1.42
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.5.2, xe48   Upstream: 1.1.1.2, xe1
  Path refresh: 30 seconds (RR enabled) (due in 29384 seconds)
  Path lifetime: 157 seconds (due in 140 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 32128 seconds)
  Resv lifetime: 157 seconds (due in 147 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Received Explicit Route Detail :
   1.1.1.1/32 strict
```

```
   1.1.5.2/32 strict
   1.1.4.1/32 strict
  Session Explicit Route Detail :
   1.1.5.2/32 strict
   1.1.4.1/32 strict
  Record route:
   ----------------------------------------------------------------
   IP Address        Label
   ----------------------------------------------------------------
   1.1.1.2
   <self>
   1.1.5.2
   1.1.4.1
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
Egress
135.1.1.27
  From: 135.1.1.42, LSPstate: Up, LSPname: BL-1.1.1.1-135.1.1.27-Bypass
  Egress FSM state: Operational
  Setup priority: 7, Hold priority: 0
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:        3,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 135.1.1.42
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Upstream: 1.1.5.2, xe48
  Path lifetime: 157 seconds (due in 147 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 21158 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Received Explicit Route Detail :
   1.1.5.1/32 strict
  Record route:
   ----------------------------------------------------------------
   IP Address        Label
   ----------------------------------------------------------------
   1.1.3.2
   1.1.5.2
   <self>
  Style: Shared Explicit Filter
```

```
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
Transit
135.1.1.42
  From: 135.1.1.43, LSPstate: Up, LSPname: BL-1.1.2.2-135.1.1.42-Bypass
  Transit upstream state: Operational, downstream state: Operational
  Setup priority: 2, Hold priority: 2
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in:    25602,  Label out:        3,
  Tspec rate: 0, Fspec rate: 0
  Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 135.1.1.43
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.1.2, xe1   Upstream: 1.1.5.2, xe48
  Path refresh: 30 seconds (RR enabled) (due in 29400 seconds)
  Path lifetime: 157 seconds (due in 147 seconds)
  Resv refresh: 30 seconds (RR enabled) (due in 40649 seconds)
  Resv lifetime: 157 seconds (due in 140 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Received Explicit Route Detail :
   1.1.5.1/32 strict
   1.1.1.2/32 strict
  Session Explicit Route Detail :
   1.1.1.2/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   1.1.4.1
   1.1.5.2
   <self>
   1.1.1.2
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_CONFIG
  CLASS    DSCP_value     EXP_value
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
```

```
  Trunk Type: mpls
Ingress (Primary)
135.1.1.44
  From: 135.1.1.27, LSPstate: Up, LSPname: PE1-PE4-1-Primary
  Ingress FSM state: Operational
  Establishment Time: 0s 16ms
  Setup priority: 7, Hold priority: 0, HOP limit: 255
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 30
  LSP Protection: facility
  Fast-Reroute bandwidth : 0
  Protection type desired: Node
  Fast-Reroute Hop limit: 255
  Fast-Reroute Setup priority: 7, Hold priority: 0
  Bypass trunk: BN-135.1.1.42-135.1.1.43,  Merge Point: 1.1.2.1,  MP Label: 25600
    Bypass OutLabel: 25604,  OutIntf: xe48
    Protection provided -> Type: Node, BW: Best-effort, Match-Code: Perfect-match
  Label in: -,  Label out:    25600,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5002, LSP Id: 2202, Ext-Tunnel Id: 135.1.1.27
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.1.2, xe1
  Path refresh: 30 seconds (RR enabled) (due in 29192 seconds)
  Resv refresh: 0 seconds (due in 1 seconds)
  Resv lifetime: 157 seconds (due in 140 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Enabled
  Admin Groups: none
  Configured Path: PE1-PE4-1 (in use)
  Configured Explicit Route Detail :
   1.1.1.2/32 strict
   1.1.2.1/32 strict
   1.1.6.1/32 strict
  Session Explicit Route Detail :
   1.1.1.2/32 strict
   1.1.2.1/32 strict
   1.1.6.1/32 strict
  Record route:
   LP = 1 -> PLR's Downstream link is protected      PU = 1 -> Protection is in use on
PLR
   NP = 1 -> PLR's Downstream neighbor is protected  BP = 1 -> BW protection available
at PLR
   -------------------------------------------------------------
   IP Address        Label     (LP, PU, NP, BP)
   -------------------------------------------------------------
   <self>
   1.1.1.2           25600     ( 1,  0,  0,  0)
   1.1.2.1           25600     ( 0,  0,  0,  0)
```

```
   1.1.6.1           25600     ( 0,  0,  0,  0)
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
```

Verify particular Bypass session detail information:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43
Ingress (Bypass)
135.1.1.43
  From: 135.1.1.27, LSPstate: Up, LSPname: BN-135.1.1.42-135.1.1.43-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 11ms
  Setup priority: 7, Hold priority: 0, HOP limit: 255
  Auto-bypass Info: Exclude-Node 135.1.1.42, Egress 135.1.1.43, Cspf ISIS
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Enabled, Re-Optimization Timer: 1 minutes, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 20
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    25604,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2203, Ext-Tunnel Id: 135.1.1.27
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.5.2, xe48
  Path refresh: 30 seconds (RR enabled) (due in 29807 seconds)
  Resv lifetime: 157 seconds (due in 157 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: none
  Exclude Node: 135.1.1.42
  Session Explicit Route Detail :
   1.1.5.2/32 strict
   1.1.4.1/32 strict
  Record route:
   --------------------------------------------------------------
   IP Address        Label
   --------------------------------------------------------------
   <self>
```

```
   1.1.5.2
   1.1.4.1
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
  Total LSP protected : 1, Bandwidth in use : 0
```

Verify using below show command for LSP's Protected by the Bypass tunnel:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43 protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2
- Node protection miss,
            3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id  Lsp-Id    Lsp-Name                   Role      Ext_tnl_id      Ingress
Egress           Match-Code Mapped-BW
5002      2202       PE1-PE4-1-Primary                Ingress    135.1.1.27
135.1.1.27       135.1.1.44       0          NA
Total LSP protected : 1
 Bandwidth in use : 0
```

Verify using below show command for mpls forwarding-table information:

```
PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
       L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
       U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
       (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled
Code    FEC               FTN-ID    Nhlfe-ID  Tunnel-id   Pri   LSP-Type     Out-Label    Out-Intf    ELC   Nexthop
R(b)>   135.1.1.43/32     15        37        5001        Yes   LSP_DEFAULT  25604        xe48        No    1.1.5.2
R(t)>   135.1.1.44/32     9         19        5002        Yes   LSP_DEFAULT  25600        xe1         No    1.1.1.2
R(t)>   135.1.1.44/32     14        38        5002        No    LSP_DEFAULT  25600        xe48        No    135.1.1.43
                                                                                        (via 1.1.5.2, label 25604)
```

(via 1.1.5.2, label 25604)

Shutdown the primary path and verify for node protection functionality:

Shutdown interface between PE1-P1, so that primary path goes Down and backup in use.

```
config)#interface xe1
(config-if)#shutdown
(config-if)#commit
```

Verify auto bypass sessions summary information:

```
PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime     Rt  Style  Labelin  Labelout
135.1.1.43      135.1.1.27      5001     2203     BPS    BN-135.1.1.42-135.1.1.43-Bypass
UP    00:06:18  1 3 SE     -        25604
135.1.1.44     135.1.1.27     5002    2202    PRI   PE1-PE4-1-Primary            BU
00:16:53  1 3 SE     -        25600
135.1.1.44     135.1.1.27     5002    2201    PRI   PE1-PE4-1-Primary            DN
N/A       0 0 SE     -        -
Total 3 displayed, Up 2, Down 1.

Egress RSVP:
To              From            Tun-ID   LSP-ID   Type   LSPName
State Uptime     Rt  Style  Labelin  Labelout
135.1.1.27     135.1.1.44     5001    2201    PRI   Pe4-Pe1-Primary              UP
00:16:47  1 1 SE     25600    -
135.1.1.27      135.1.1.42      5002     2202     PRI    BL-1.1.1.1-135.1.1.27-Bypass
UP    00:13:32  1 1 SE     3        -
Total 2 displayed, Up 2, Down 0.
```

Verify particular Bypass session detail information:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43
Ingress (Bypass)
135.1.1.43
  From: 135.1.1.27, LSPstate: Up, LSPname: BN-135.1.1.42-135.1.1.43-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 11ms
  Setup priority: 7, Hold priority: 0, HOP limit: 255
```

```
  Auto-bypass Info: Exclude-Node 135.1.1.42, Egress 135.1.1.43, Cspf ISIS
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Enabled, Re-Optimization Timer: 1 minutes, Cspf Client: ISIS
  IGP-Shortcut: Disabled, LSP metric: 20
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    25604,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2203, Ext-Tunnel Id: 135.1.1.27
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 1.1.5.2, xe48
  Path refresh: 30 seconds (RR enabled) (due in 29602 seconds)
  Resv lifetime: 157 seconds (due in 155 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: none
  Exclude Node: 135.1.1.42
  Session Explicit Route Detail :
   1.1.5.2/32 strict
   1.1.4.1/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
   <self>
   1.1.5.2
   1.1.4.1
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
Recorded Time : N/A
  Current Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Last Signaled Error:
    Code : None, Value : None
    Originated Node : None, Recorded Time : N/A
  Trunk Type: mpls
  Total LSP protected : 1, Bandwidth in use : 0
```

Verify using below show command for MPLS forwarding-table information:

```
PE1#show mpls forwarding-table
Codes: > - installed FTN, * - selected FTN, p - stale FTN, ! - using backup
       B - BGP FTN, K - CLI FTN, (t) - tunnel, P - SR Policy FTN, (b) - bypass,
```

```
      L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
      U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN
      (m) - FTN mapped over multipath transport, (e) - FTN is ECMP

FTN-ECMP LDP: Disabled
Code    FEC               FTN-ID   Nhlfe-ID  Tunnel-id   Pri   LSP-Type    Out-Label
Out-Intf    ELC   Nexthop
R(b)>   135.1.1.43/32      15       37        5001        Yes   LSP_DEFAULT  25604
xe48        No    1.1.5.2
R(t)!   135.1.1.44/32      9        19        5002        Yes   LSP_DEFAULT  25600
xe1         No    1.1.1.2
R(t)>   135.1.1.44/32      14       38        5002        No    LSP_DEFAULT  25600
xe48        No    135.1.1.43
                                                                                  (via
1.1.5.2, label 25604)
```

Verify using below show command for LSP's Protected by the Bypass tunnel:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43 protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2
- Node protection miss,
            3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id  Lsp-Id    Lsp-Name                   Role      Ext_tnl_id      Ingress
Egress           Match-Code Mapped-BW
5002       2202       PE1-PE4-1-Primary                 Ingress    135.1.1.27
135.1.1.27       135.1.1.44       0          NA
Total LSP protected : 1
 Bandwidth in use : 0
```

Auto Bypass and Manual Bypass Co-exists with Perfect Protection

Manual bypass and auto bypass coexist and when manual bypass already providing perfect protection, then manual bypass preferred over auto bypass. auto bypass won't be triggered.

Auto bypass is created when Manual bypass is provided with perfect protection as link

Snippet configuration on PE1 router for Auto-bypass is as follows:

```
#show running-config
!
router rsvp
 auto-bypass
  attributes best-effort
   protection-capability link
   reoptimize
   exit
  inactivity-timer 5
  enable
  exit
!
```

Snippet configuration on PE1 router for Manual-bypass is as follows:

```
 !
rsvp-path backup-PE1-P4-P1 mpls
 1.1.5.2 strict
 1.1.3.2 strict
!
rsvp-bypass backup-to-p1
 path backup-PE1-P4-P1
 to 135.1.1.44
!
```

Validation

Verify all sessions including auto bypass sessions summary information:

Manual bypass and auto bypass coexist and when manual bypass already providing perfect protection, auto bypass session goes down when manual bypass exists.

Verify all RSVP sessions information: The output shows only manual bypass session information when Manual bypass and auto bypass coexist and when manual bypass already providing perfect protection.

```
PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To               From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.44     135.1.1.27     5001    2205    PRI    PE1-PE4-Primary             UP
00:16:19  1 1 SE     -        25604
135.1.1.44     135.1.1.27     5002    2206    PRI    PE1-PE4-1-Primary           UP
00:16:21  1 1 SE     -        25602
135.1.1.44     135.1.1.27     5003     2203     BPS    backup-to-p1-Bypass
UP    00:05:18  1 1 SE     -        25601
Total 3 displayed, Up 3, Down 0.

Transit RSVP:
To               From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.28     135.1.1.42     5002     2202     PRI    BL-1.1.9.1-135.1.1.28-Bypass
UP    00:16:19  1 1 SE     25601    3
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To               From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.27     135.1.1.42     5001     2201     PRI    BL-1.1.1.1-135.1.1.27-Bypass
UP    00:16:37  1 1 SE     3        -
135.1.1.27     135.1.1.44     5001    2201    PRI    Pe4-Pe1-Primary             UP
00:16:37  1 1 SE     25600    -
Total 2 displayed, Up 2, Down 0.
```

Verify using below show command for LSP's Protected by the Bypass tunnel:

```
PE1#show rsvp bypass BN-135.1.1.42-135.1.1.43 protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2
- Node protection miss,
            3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id  Lsp-Id    Lsp-Name                   Role      Ext_tnl_id      Ingress
Egress           Match-Code Mapped-BW
5001       2205       PE1-PE4-1-Primary               Ingress    135.1.1.27
135.1.1.27       135.1.1.44       2          NA
5002       2206       PE1-PE4-1-Primary               Ingress    135.1.1.27
135.1.1.27       135.1.1.44       2          NA
Total LSP protected : 1
 Bandwidth in use : 0
```

Auto Bypass with Node Protection and Manual Bypass with Link Protection

Snippet configuration on PE1 router for Auto-bypass is as follows:

```
!
router rsvp
 auto-bypass
  attributes best-effort
   protection-capability node
   reoptimize
   exit
  inactivity-timer 5
  enable
  exit
!
```

Snippet configuration on PE1 router for Manual-bypass is as follows:

```
 !
rsvp-path backup-PE1-P4-P1 mpls
 1.1.5.2 strict
 1.1.3.2 strict
!
rsvp-bypass backup-to-p1
 path backup-PE1-P4-P1
 to 135.1.1.44
!
```

Validation

Verify all sessions including auto bypass sessions summary information: The output shows that

Manual bypass for link protection is UP and auto bypass for node protection is UP and running.

```
PE1#show rsvp session
Type  : PRI - Primary, SEC - Secondary, DTR - Detour, BPS - Bypass
State : UP - Up, DN - Down, BU - Backup in Use, SU - Secondary in Use, FS - Forced to
Secondary
* indicates the session is active with local repair at one or more nodes
(P) indicates the secondary-priority session is acting as primary

Ingress RSVP:
To               From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.44     135.1.1.27     5001    2205    PRI   PE1-PE4-Primary              UP
00:22:44  1 1 SE     -       25604
135.1.1.44     135.1.1.27     5002    2206    PRI   PE1-PE4-1-Primary            UP
00:22:46  1 1 SE     -       25602
135.1.1.44      135.1.1.27      5003     2203     BPS    backup-to-p1-Bypass
UP    00:11:43  1 1 SE     -        25601
135.1.1.28      135.1.1.27      5004     2201     BPS    BN-135.1.1.42-135.1.1.28-Bypass
UP    00:05:17  1 1 SE     -        3
135.1.1.43      135.1.1.27      5006     2204     BPS    BN-135.1.1.42-135.1.1.43-Bypass
UP    00:05:17  1 1 SE     -        25602
Total 5 displayed, Up 5, Down 0.

Transit RSVP:
To               From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.28      135.1.1.42      5002     2202     PRI    BL-1.1.9.1-135.1.1.28-Bypass
UP    00:22:44  1 1 SE     25601    3
Total 1 displayed, Up 1, Down 0.

Egress RSVP:
To               From            Tun-ID   LSP-ID   Type   LSPName
State Uptime    Rt  Style  Labelin  Labelout
135.1.1.27      135.1.1.42      5001     2201     PRI    BL-1.1.1.1-135.1.1.27-Bypass
UP    00:23:02  1 1 SE     3        -
135.1.1.27     135.1.1.44     5001    2201    PRI   Pe4-Pe1-Primary              UP
00:23:02  1 1 SE     25600    -
Total 2 displayed, Up 2, Down 0.
```

Verify using below show command for LSP's Protected by the Bypass tunnels:

```
PE1#sh rsvp bypass protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2
- Node protection miss,
            3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: backup-to-p1
```

```
Bypass trunk bandwidth type: best-effort
Total LSP protected : 0
 Bandwidth in use : 0

Bypass trunk: BN-135.1.1.42-135.1.1.43
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id  Lsp-Id    Lsp-Name                   Role      Ext_tnl_id     Ingress
Egress           Match-Code Mapped-BW
5006       2207       PE1-PE4-1-Primary                Ingress    135.1.1.27
135.1.1.27       135.1.1.44       0          NA
Total LSP protected : 1
 Bandwidth in use : 0

Bypass trunk: BN-135.1.1.42-135.1.1.28
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id  Lsp-Id    Lsp-Name                   Role      Ext_tnl_id     Ingress
Egress           Match-Code Mapped-BW
5004       2205       PE1-PE4-Primary                  Ingress    135.1.1.27
135.1.1.27       135.1.1.44       0          NA
Total LSP protected : 1
 Bandwidth in use : 0
```

RSVP Auto Bypass Commands

The RSVP auto bypass introduces the following configuration commands within the Facility Backup commands.

auto-bypass

Use this command to enter a new mode of auto-bypass to configure auto bypass specific commands and enable auto bypass feature.

Use the `no` parameter to auto bypass configurations. When configuration removed at global level, all auto bypass configuration will be removed and all dynamically created bypass tunnels will be deleted.

Command Syntax

```
auto-bypass
no auto-bypass
```

Parameters

None

Default

Disabled

Command Mode

Router mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for configuring auto bypass:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#exit
(config-router)#no auto-bypass
```

auto-bypass enable

Use this command to enable or disable auto bypass functionality. When this functionality is enabled, sessions requesting facility backup protection will attempt creation of bypass tunnels dynamically, if no satisfying bypass protection is available. If topology supports the formation of dynamically created bypass session, then the sessions will be protected by dynamically created bypass tunnels.

When manual bypass created, which satisfies protection requirement similar to auto bypass tunnels, then manual bypass tunnel gets preference over auto bypass tunnels. However, if auto bypass tunnels provide better protection (based on session request) than manual bypass, then auto bypass tunnels considered for protection over manual bypass tunnels.

Use the `disable` parameter to disable the auto bypass functionality. When this functionality is disabled, all dynamically created bypass tunnels will be deleted.

Command Syntax

```
enable
disable
```

Parameters

None

Default

Disabled

Command Mode

Auto bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for enabling the auto bypass:

```
#configure terminal
(config)#router rsvp
```

```
(config-router)#auto-bypass
(config-auto-bypass)#enable
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

This example is for disabling the auto bypass:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#disable
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

inactivity-timer

Use this command to configure inactivity timer for auto bypass tunnels. When auto bypass tunnels do not protect any session, inactivity timer will decide how long to retain the auto bypass tunnels before deleting them. If auto bypass tunnel starts protecting any session, then inactivity timer will be stopped.

Use the `no` parameter to reset auto bypass inactivity timer to default value.

Command Syntax

```
inactivity-timer <1-240>

no inactivity-timer
```

Parameters

`inactivity-timer <1-240>`	Specifies the RSVP auto bypass inactivity timer in minutes. This timer determines the maximum time that dynamically created auto bypass tunnels can remain inactive before being deleted. The default value is 60 minutes.

Default

None

Command Mode

Auto bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for setting the inactivity timer to 5 minutes:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#inactivity-timer 5
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

attributes

Use this command to configure auto bypass attributes. Currently only best-effort type auto bypass tunnels supported and hence user can modify the attributes of best-effort type auto bypass. This command takes to new mode in which several parameters can be configured. The parameters configured in this mode are applicable to auto bypass sessions of attribute type.

Use the `no` parameter to reset auto bypass attributes of matching type to default values.

Command Syntax

```
attributes best-effort
no attributes best-effort
```

Parameters

`best-effort`	Specifies the auto bypass attribute configuration for the best-effort type in auto bypass.

Default

The initial configuration for best-effort auto bypass attributes is not set, and the internal entities have their default settings.

Command Mode

Auto bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

This example is for configuring auto bypass attributes:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

This example is to reset auto bypass attributes of matching type to default values:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
(config-auto-bypass)#no attributes best-effort
(config-auto-bypass)#commit
(config-auto-bypass)#exit
```

protection-capability

Use this command to set the protection capability attribute for auto bypass. Capability setting decides the types of auto bypass tunnels allowed to be attempted. When capability configured as link, only exclude link type of bypass creation will be attempted and provides protection against only link failure. When capability node is configured, if session requests for node protection, then exclude node type bypass will also be created along with exclude link type bypass and provides the best protection possible. Even when capability configured as node, if session doesn't request for node protection, then node protecting bypass formation will not be attempted.

Use the `no` parameter to reset the attribute to default value which is capability type node.

Command Syntax

```
protection-capability (link | node)
no protection-capability
```

Parameters

`link`	Specifies the capability for link protection only.
`node`	Specifies the capability for link and node protection.

Default

The value for protection capability is `node`.

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the protection capability attribute to `link`:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#protection-capability link
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the protection capability attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no protection-capability
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

bandwidth

Use this command to set the bandwidth attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this bandwidth constraint while requesting for an LSP to CSPF.

Use the `no` parameter to remove bandwidth attribute and auto bypass sessions will not request any bandwidth constraint to form LSP.

Command Syntax

```
bandwidth BANDWIDTH
no bandwidth
```

Parameters

`BANDWIDTH`	Specifies the bandwidth attribute for auto bypass within the range of 1k to 100g. The default value is zero.

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the bandwidth attribute to `100g`:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#bandwidth 100g
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the bandwidth attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no bandwidth
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

setup-priority

Use this command to set the setup priority attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this setup priority constraint while requesting for an LSP to CSPF.

Use the `no` parameter to reset setup priority attribute to default value.

Command Syntax

```
setup-priority <0-7>
no setup-priority
```

Parameters

`setup-priority <0-7>`	Specifies the attribute for Auto bypass setup priority. The default value for attribute for setup priority is 7.

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.0.

Example

Example for setting up the setup priority attribute to `5`.

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass attributes best-effort
(config-auto-bypass-attr)#setup-priority 5
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the setup priority attribute to default value.

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass attributes best-effort
(config-auto-bypass-attr)#no setup-priority
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

hold-priority

Use this command to set the hold priority attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this hold priority constraint while requesting for an LSP to CSPF.

Use the `no` parameter to reset hold priority attribute to default value.

Command Syntax

```
hold-priority <0-7>
no hold-priority
```

Parameters

`hold-priority <0-7>`	Specifies the attribute for Auto bypass hold priority. The default value is 0.

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the hold priority attribute to `2`:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#hold-priority 2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the hold priority attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no hold-priority
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

hop-limit

Use this command to set the hop limit attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this hop limit constraint while requesting for an LSP to CSPF.

Use the `no` parameter to reset hop limit attribute to default value.

Command Syntax

```
hop-limit <1-255>
no hop-limit
```

Parameters

`hop-limit <1-255>`	Specifies the attribute for Auto bypass hop limit. The default value is 255.

Default

None

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for setting up the hop limit attribute to 5:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#hop-limit 5
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to reset the hop limit attribute to default value:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no hop-limit
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

reoptimize

Use this command to set the re-optimization attribute for auto bypass. Auto bypass sessions of matching attribute type will be enabled for re-optimization when the attribute is configured.

Use the `no` parameter to disable re-optimization for auto bypass.

Command Syntax

```
reoptimize

no reoptimize
```

Parameters

None

Default

The auto bypass re-optimization is disabled.

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for enabling the re-optimization attribute:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#reoptimize
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example for disabling the re-optimization attribute:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no reoptimize
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

exclude-address

Use this command to configure exclude address attribute for auto bypass. Auto bypass sessions of matching attribute type will inherit this explicit exclude address constraint while requesting for an LSP to CSPF. CSPF will provide the auto bypass path excluding the implicit exclude address and the configured exclude addresses.

Note: When link address added for exclusion, next-hop address on the link must be configured to exclude the link in forward direction and also if the link must be excluded in both direction, then both link address and the next-hop address must be added to exclude address list. For node address exclusion, it is recommended to configure the loopback address which is part of routing.

Use the `no` parameter to remove the exclude address constraint.

Command Syntax

```
exclude-address (link | node) A.B.C.D
no exclude-address (link | node) A.B.C.D
```

Parameters

`link A.B.C.D`	Specifies the exclude address of type link.
`node A.B.C.D`	Specifies the exclude address of node link.

Default

Auto bypass will only have an implicit exclude address, which is the immediate link or node of the protected session. No additional exclude address constraints are applied.

Command Mode

Auto bypass attribute mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for configuring exclude address attribute to `link 10.1.1.2`:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#exclude-address link 10.1.1.2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example for configuring exclude address attribute to `node 2.2.2.2`:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#exclude-address node 2.2.2.2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Example to remove the exclude address constraint from `link 10.1.1.2`:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bypass
(config-auto-bypass)#attributes best-effort
(config-auto-bypass-attr)#no exclude-address link 10.1.1.2
(config-auto-bypass-attr)#commit
(config-auto-bypass-attr)#exit
```

Show Commands - RSVP Auto Bypass

show rsvp router-id-table

Use this command to display the mapping of link addresses to router IDs maintained by the RSVP module to reduce the number of CSPF query.

Note: This command can display no information even when auto bypass sessions are active but that is just an indication that RSVP module doesn't hold the CSPF data locally and will collect data from CSPF when required.

Command Syntax

```
show rsvp router-id-table
```

Parameters

None

Command Mode

Exec and Privileged exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing RSVP router ID table:

```
#show rsvp router-id-table
Link Address     Router ID        Query Status     CSPF Client    Refcnt
----------------+----------------+----------------+--------------+---------
23.1.1.3         3.3.3.3          COMPLETE         ISIS           3
```

show rsvp srlg-group

This command displays mapping of unique ID value used in auto bypass name to the SRLG group when srlg-disjoint is configured.

Note that, only OSPF CSPF provides SRLG protection. SRLG configuration not recommended to be configured when CSPF is ISIS.

Command Syntax

```
show rsvp srlg-group
```

Parameters

None

Command Mode

Exec and Privileged exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing SRLG group:

```
#show rsvp srlg-group
Group-ID   Refcnt     SRLG Values
----------+----------+----------------------------------------------------
100        3          10
```

show rsvp srlg-group parameters output details

Field	Description
Group-ID	A unique ID generated for a set of SRLG values. This ID is used in tunnel name to maintain SRLG uniqueness.
Refcnt	Number of auto bypass tunnels using the group ID in their name.
SRLG Values	A set of SRLG values for which a unique ID is generated.

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
CSPF	**Constrained Shortest Path First**. An extension of shortest path first (SPF). The path computed using CSPF is the shortest path that fulfills a set of constraints. After running the shortest path algorithm, the paths are pruned, removing those links that violate a given set of constraints.
LSP	**Label Switched Path**. A sequence of routers that cooperatively perform Multi-Protocol Label Switching (MPLS) operations for a packet stream. An LSP is a unidirectional, point-to-point, half-duplex connection carrying information downstream from the ingress (first) router to the egress (last) router. The ingress and egress routers cannot be the same device.
OSPF	**Open Shortest Path First.** An Interior Gateway Protocol (IGP) based on link-state routing. OSPF is widely deployed in large networks because of its efficient use of network bandwidth and its rapid convergence after changes in topology.
PLR	**Point of Local Repair**. It refers to a router's capability within a network to quickly reroute traffic around a failed link or node.
RSVP	**Resource Reservation Protocol**. A signalling protocol for reserving resources across a network. RSVP is rarely used by itself, but Resource Reservation Protocol—Traffic Engineering (RSVP-TE) is widely used.
SRLG	**Shared Risk Link**. Group. It refers to a group of links that share a common risk of failure due to factors such as physical proximity, geographic location, or shared resources.

CHAPTER 7 Auto-Bandwidth with RSVP-TE

Overview

Automatic bandwidth allows to dynamically adjust bandwidth reservation based on the measured traffic. RSVP automatic bandwidth monitors the traffic rate on a Label Switched Path (LSP) and resizes the bandwidth to align it closely with the traffic in the tunnel. RSVP automatic bandwidth is configured on individual LSPs at every headend router.

Auto bandwidth can be added to an operational LSP at any time, but no bandwidth change occurs until a future trigger event or auto bandwidth profile configured with initial bandwidth or minimum bandwidth. Auto bandwidth may also be removed from an operational LSP at any time and this would re-signal the LSP with no bandwidth reservation.

Feature Characteristics

The characteristics of the RSVP auto-bandwidth are:

- RSVP-TE auto bandwidth provides the means to automatically adjust the bandwidth allocation for traffic engineering tunnels based on their measured traffic load.
- This feature samples the average output rate for each tunnel marked for automatic bandwidth adjustment. For each marked tunnel, this feature periodically adjusts the tunnel's allocated bandwidth to the largest eligible sample for the tunnel since the last adjustment.
- The frequency with which tunnel bandwidth is adjusted and the allowable range of adjustments should be configurable on a per-auto-bandwidth profile basis.
- In addition, the sampling interval and the interval over which to average tunnel traffic to obtain the average output rate is user-configurable on a per-auto-bandwidth profile basis.

Note:

- Convergence on redundancy may require bidirectional traffic or MAC aging.
- The feature relies on stat_id allocation to tunnel entities, and there is a limit on the maximum number of stat_ids (which varies based on the chip variant). If a tunnel is not associated with a stat entity, traffic rate samples cannot be fetched for those tunnels.
- RSVP Graceful Restart is not supported for automatic bandwidth. When a GR is performed, RSVP will not store the current bandwidth for the reservation. It will use either the initial bandwidth (if configured), the minimum bandwidth, or the highest bandwidth of the on-boot sample (if auto-bandwidth-on-boot is configured).
- The auto bandwidth feature relies on the hardware's ability to collect tunnel traffic counters. In Qumran1 devices, the “hardware-profile statistics tunnel-lif enable” command must be enabled, and the system must be reloaded for the change to take effect. Without the tunnel statistics profile, auto bandwidth will not process traffic rates and will be ineffective. Note that, only 2 statistics profiles shall be configured as this is the hardware limitation.
- Auto bandwidth and manual bandwidth configurations are mutually exclusive. Auto bandwidth allows for configuring an initial bandwidth, which will be used as the session's initial bandwidth when auto bandwidth is associated with a trunk. If the initial bandwidth is not configured, the minimum bandwidth will be used to initialize the session bandwidth.
- For tunnels with only one hop, the no PHP (default config) must be set for the rate to be computed correctly.

Benefits

In large MPLS transport networks in service provider settings with this capability:

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- The network can react faster to sudden bursts of traffic in near real-time and not rely on manual intervention.
- Effective use of bandwidth resources by minimizing the over-subscription/padding of LSP bandwidth.
- Maximizes the usage of available bandwidth and optimizes the network effectively to use preferred, shorter latency, paths first.

Prerequisites

Define Interfaces and Loopback Addresses

Configure Layer 3 interfaces, like port channel interfaces (e.g., po1), and assign specific IP addresses for proper identification and routing. Additionally, assign loopback IP addresses to establish essential points of connectivity. These configurations establish the efficient network routing and communication.

```
!
interface lo
 ip address 127.0.0.1/8
 ip address 100.1.1.1/32 secondary
 ipv6 address ::1/128
!
interface xe1
 ip address 1.1.1.1/24
!
```

Configure IGP for Dynamic Routing

Configure IGP for dynamic routing by following the steps mentioned. This setup includes enabling ISIS for dynamic routing and configuring OSPF for the network.

ISIS Configuration

1. **Enable ISIS on all nodes**: Ensure that ISIS is running across the network to facilitate dynamic routing.
2. **Define ISIS Router Instances**: Set up instances to match loopback IP addresses.
3. **Add Network Segments to ISIS Areas**: This ensures proper route distribution.
4. **Set up Neighbor Relationships**: Use loopback IP addresses to establish these relationships for efficient route advertisement and convergence.

```
!
router isis 1
 is-type level-2-only
 metric-style wide
 mpls traffic-eng router-id 100.1.1.1
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 fast-reroute ti-lfa level-2 proto ipv4
 net 49.0000.0000.0001.00
 passive-interface lo
!
interface xe1
 isis network point-to-point
```

```
 ip router isis 1
!
```

OSPF Configuration

1. **Configure OSPF Router ID**: Assign a unique router ID for OSPF operations.
2. **Define OSPF Networks**: Include the loopback IP and other network segments in the OSPF area for route distribution.

```
!
router ospf 100
 ospf router-id 100.1.1.1
 network 100.1.1.1/32 area 0.0.0.0
 network 1.1.1.1/24 area 0.0.0.0
!
```

Configure RSVP for Efficient Network Operation

Enable Resource Reservation Protocol (RSVP) on all nodes to optimize traffic routing and quality of service. RSVP reserves network resources along specified paths to enhance network performance and reliability.

```
!
router rsvp
!
interface xe1
 label-switching
 enable-rsvp
!
```

Configure the RSVP Primary Path and Trunk

Establish a trunk is required on edge routers participating in label-switching using defined path. Configuring the RSVP path is optional.

```
!
rsvp-path PE1-PE2-1 mpls
 1.1.1.2 strict
 1.1.2.1 strict
!
rsvp-trunk PE1-PE2 ipv4
 reoptimize
 primary fast-reroute protection facility
 primary fast-reroute node-protection
 primary path PE1-PE2-1
 from 100.1.1.1
 to 100.1.1.3
!
```

Configuration for RSVP Auto-Bandwidth

Configure various nodes within the topology to set up a RSVP-Auto bypass tunnels.

Topology

The sample topology includes Edge Nodes (PE1 and PE2) and core Nodes (P1).

Primary path is defined via PE1-P1-PE2.

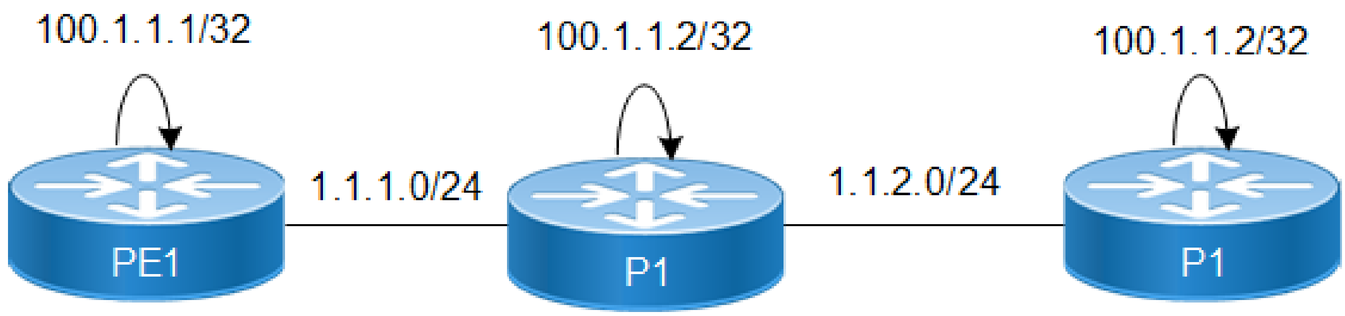

Figure 7-4: RSVP-Auto Bypass Tunnel Setup

Configure RSVP Auto Bandwidth on PE1 Router

1. Create auto-bandwidth Profile.

```
(config)# rsvp-auto-bandwidth AUTO-BW
(config-auto-bandwidth)# commit
```

2. Set the Sample interval & adjust interval.

```
(config-auto-bandwidth)# sample-interval 1
(config-auto-bandwidth)# adjust-interval 5
```

3. Set the minimum & maximum bandwidth rate.

```
(config-auto-bandwidth)# minimum-bandwidth 200m
(config-auto-bandwidth)# maximum-bandwidth 500m
```

4. Set the overflow-threshold & underflow-threshold.

```
(config-auto-bandwidth)# overflow-threshold absolute 100m
(config-auto-bandwidth)# underflow-threshold absolute 50m
```

5. Set the overflow & underflow limit.

```
(config-auto-bandwidth)# overflow-limit 2
(config-auto-bandwidth)# underflow-limit 2
```

6. Set the maximum number of consecutive times the average bandwidth can exceed the maximum threshold bandwidth before the exceed action is applied.

```
(config-auto-bandwidth)# maximum-bandwidth-exceed-limit 2
(config-auto-bandwidth)#maximum-bandwidth-exceed-action teardown
(config-auto-bandwidth)#commit
```

Running configuration on PE1 router is as follows:

```
#show running-config rsvp
!
router rsvp
!
!
interface xe1
 enable-rsvp
!
interface xe2
 enable-rsvp
!
```

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```
!
!
!
rsvp-auto-bandwidth AUTO-BW
 sample-interval 1
 adjust-interval 5
 minimum-bandwidth 200m
 maximum-bandwidth 500m
 overflow-threshold absolute 100m
 underflow-threshold absolute 50m
 overflow-limit 2
 underflow-limit 2
 maximum-bandwidth-exceed-limit 2
 maximum-bandwidth-exceed-action teardown
!
rsvp-trunk PE1-PE2 ipv4
 reoptimize
 primary fast-reroute protection facility
 primary fast-reroute node-protection
 primary path PE1-PE2-1
 auto-bandwidth AUTO-BW
 from 100.1.1.1
 to 100.1.1.3
!
```

Validation

Verify auto bandwidth adjustments information as below:

```
Send the sample rate with 200MBPS and verify the auto bandwidth adjustments as below:

#show rsvp trunk auto-bandwidth detail
Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2202, Egress: 100.1.1.3
---------------------------------------------------------------------------------------
Sample Interval                         : 1 minutes
Adjustment Interval                     : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth                : 0
Minimum Bandwidth                       : 200m
Maximum Bandwidth                       : 500m
Overflow Threshold Bandwidth            : 100m
Underflow Threshold Bandwidth           : 50m
Overflow Threshold Activate Bandwidth   : 0
Underflow Threshold Activate Bandwidth  : 0
Overflow Limit                          : 2
Underflow Limit                         : 2
Max. Bandwidth Exceed Limit             : 2
---------------------------------------------------------------------------------------
Max-BW-exceed-limit action              : teardown
Resignal-failure-action                 : notify
Monitor Bandwidth                       : No
---------------------------------------------------------------------------------------
```

```
Minimum Average Bandwidth                : 0
Maximum Average Bandwidth                : 202.8m
Total Overflow Count                     : 0
Consecutive Overflow Count               : 0
Consecutive Eligible Overflow Count      : 0
Total Underflow Count                    : 0
Consecutive Underflow Count              : 0
Consecutive Eligible Underflow Count     : 0
Max. Bandwidth Exceed Count              : 0
Teardown Count                           : 0
---------------------------------------------------------------------------------------
Last Bandwidth                           : 0
Last Requested Bandwidth                 : 0
Last Signaled Bandwidth                  : 0
Current Bandwidth                        : 200m
Highest Bandwidth                        : 203m
---------------------------------------------------------------------------------------
Time for Next Sample request             : 48 seconds
Time for Next Adjustment                 : 2 minutes, 57 seconds
Time of Last Bandwidth Request           : N/A
Time of Last Bandwidth Signal            : N/A
Time of Last Adjustment                  : N/A
Time of Highest Bandwidth Marked         : 2024 Jun 25 09:56:19
---------------------------------------------------------------------------------------
Total Auto-Bandwidth Adjustments         : 0
Successful Adjustments                   : 0
Failed Adjustments                       : 0
---------------------------------------------------------------------------------------
Samples collected in the current adjustment cycle:
  [Sample 1-5]       : 202.8m   202.6m


#show rsvp trunk auto-bandwidth
--------------------+--------+--------+--------+----------+----------+----------+------
----+------------+--------------------
Trunk-Name         Trunk    LSP     Last     Requested  Signaled   Current    Highest
Adjust-Time  Last-Adjust
                   ID       ID       BW       BW         BW         BW         BW
Left(sec)    Time
--------------------+--------+--------+--------+----------+----------+----------+------
----+------------+--------------------
PE1-PE2    5002     2202    0       0         0         200m      203m      176
NA
```

Overflow:

Current bandwidth is adjusted to 290.4MBPS. Then, send the sample rate which is more than overflow threshold i.e, 340.1MBPS , 377.2MBPS.

As per the below output current bandwidth is more than overflow threshold bandwidth and consecutively two samples are received and it is more than the overflow limit.

So current BW is adjusted to 377.2mbps after 2 consecutive samples collected as per the Maximum Average Bandwidth.

```
#show rsvp trunk auto-bandwidth detail
Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2202, Egress: 100.1.1.3
-----------------------------------------------------------------------------------------
Sample Interval                          : 1 minutes
Adjustment Interval                      : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth                 : 200m
Minimum Bandwidth                        : 100m
Maximum Bandwidth                        : 500m
Overflow Threshold Bandwidth             : 40m
Underflow Threshold Bandwidth            : 30m
Overflow Threshold Activate Bandwidth    : 0
Underflow Threshold Activate Bandwidth   : 0
Overflow Limit                           : 2
Underflow Limit                          : 2
Max. Bandwidth Exceed Limit              : 2
-----------------------------------------------------------------------------------------
Max-BW-exceed-limit action               : teardown
Resignal-failure-action                  : notify
Monitor Bandwidth                        : No
-----------------------------------------------------------------------------------------
Minimum Average Bandwidth                : 0
Maximum Average Bandwidth                : 340.1m
Total Overflow Count                     : 1
Consecutive Overflow Count               : 1
Consecutive Eligible Overflow Count      : 1
Total Underflow Count                    : 0
Consecutive Underflow Count              : 0
Consecutive Eligible Underflow Count     : 0
Max. Bandwidth Exceed Count              : 0
Teardown Count                           : 0
-----------------------------------------------------------------------------------------
Last Bandwidth                           : 190.7m
Last Requested Bandwidth                 : 290.4m
Last Signaled Bandwidth                  : 290.4m
Current Bandwidth                        : 290.4m
Highest Bandwidth                        : 340.1m
-----------------------------------------------------------------------------------------
Time for Next Sample request             : 0 seconds
Time for Next Adjustment                 : 0 seconds
Time of Last Bandwidth Request           : 2024 Jun 25 10:28:32
Time of Last Bandwidth Signal            : 2024 Jun 25 10:28:32
Time of Last Adjustment                  : 2024 Jun 25 10:28:32
Time of Highest Bandwidth Marked         : 2024 Jun 25 10:29:35
-----------------------------------------------------------------------------------------
Total Auto-Bandwidth Adjustments         : 4
Successful Adjustments                   : 4
Failed Adjustments                       : 0
```

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```
-------------------------------------------------------------------------------------
Samples collected in the current adjustment cycle:
  [Sample 1-5]       : 340.1m



#show rsvp trunk auto-bandwidth detail
Session: PE1-PE2_1-Primary, Tunnel-id: 5002, LSP-ID: 2203, Egress: 100.1.1.3
-------------------------------------------------------------------------------------
Sample Interval                        : 1 minutes
Adjustment Interval                    : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth               : 200m
Minimum Bandwidth                      : 100m
Maximum Bandwidth                      : 500m
Overflow Threshold Bandwidth           : 40m
Underflow Threshold Bandwidth          : 30m
Overflow Threshold Activate Bandwidth  : 0
Underflow Threshold Activate Bandwidth : 0
Overflow Limit                         : 2
Underflow Limit                        : 2
Max. Bandwidth Exceed Limit            : 2
-------------------------------------------------------------------------------------
Max-BW-exceed-limit action             : teardown
Resignal-failure-action                : notify
Monitor Bandwidth                      : No
-------------------------------------------------------------------------------------
Minimum Average Bandwidth              : 0
Maximum Average Bandwidth              : 0
Total Overflow Count                   : 0
Consecutive Overflow Count             : 0
Consecutive Eligible Overflow Count    : 0
Total Underflow Count                  : 0
Consecutive Underflow Count            : 0
Consecutive Eligible Underflow Count   : 0
Max. Bandwidth Exceed Count            : 0
Teardown Count                         : 0
-------------------------------------------------------------------------------------
Last Bandwidth                         : 290.4m
Last Requested Bandwidth               : 377.2m
Last Signaled Bandwidth                : 377.2m
Current Bandwidth                      : 377.2m
Highest Bandwidth                      : 377.2m
-------------------------------------------------------------------------------------
Time for Next Sample request           : 59 seconds
Time for Next Adjustment               : 0 seconds
Time of Last Bandwidth Request         : 2024 Jun 25 10:30:42
Time of Last Bandwidth Signal          : 2024 Jun 25 10:30:42
Time of Last Adjustment                : 2024 Jun 25 10:30:42
Time of Highest Bandwidth Marked       : 2024 Jun 25 10:30:42
```

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```
--------------------------------------------------------------------------------------
Total Auto-Bandwidth Adjustments        : 5
Successful Adjustments                  : 5
Failed Adjustments                      : 0
--------------------------------------------------------------------------------------
Samples collected in the current adjustment cycle:
=======================================
Underflow:
```

Scenario 1 :

Current bandwidth is adjusted to 377.2 mbps. Then, send the sample rate which is less than underflow threshold i.e, 317.3 mbps , 310 mbps.

As per the below output current bandwidth is more than underflow threshold bandwidth and consecutively two samples are received and it is more than the underflow limit.

So current BW is adjusted to 317.3 mbps after 2 consecutive samples collected as per the Minimum Average Bandwidth.

```
#show rsvp trunk auto-bandwidth detail
Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2203, Egress: 100.1.1.3
--------------------------------------------------------------------------------------
Sample Interval                         : 1 minutes
Adjustment Interval                     : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth                : 200m
Minimum Bandwidth                       : 100m
Maximum Bandwidth                       : 500m
Overflow Threshold Bandwidth            : 40m
Underflow Threshold Bandwidth           : 30m
Overflow Threshold Activate Bandwidth   : 0
Underflow Threshold Activate Bandwidth  : 0
Overflow Limit                          : 2
Underflow Limit                         : 2
Max. Bandwidth Exceed Limit             : 2
--------------------------------------------------------------------------------------
Max-BW-exceed-limit action              : teardown
Resignal-failure-action                 : notify
Monitor Bandwidth                       : No
--------------------------------------------------------------------------------------
Minimum Average Bandwidth               : 317.3m
Maximum Average Bandwidth               : 0
Total Overflow Count                    : 0
Consecutive Overflow Count              : 0
Consecutive Eligible Overflow Count     : 0
Total Underflow Count                   : 1
Consecutive Underflow Count             : 1
Consecutive Eligible Underflow Count    : 1
Max. Bandwidth Exceed Count             : 0
Teardown Count                          : 0
--------------------------------------------------------------------------------------
Last Bandwidth                          : 290.4m
```

```
Last Requested Bandwidth                : 377.2m
Last Signaled Bandwidth                 : 377.2m
Current Bandwidth                       : 377.2m
Highest Bandwidth                       : 377.2m
-----------------------------------------------------------------------------------------
Time for Next Sample request            : 9 seconds
Time for Next Adjustment                : 3 minutes, 6 seconds
Time of Last Bandwidth Request          : 2024 Jun 25 10:30:42
Time of Last Bandwidth Signal           : 2024 Jun 25 10:30:42
Time of Last Adjustment                 : 2024 Jun 25 10:30:42
Time of Highest Bandwidth Marked        : 2024 Jun 25 10:30:42
-----------------------------------------------------------------------------------------
Total Auto-Bandwidth Adjustments        : 5
Successful Adjustments                  : 5
Failed Adjustments                      : 0
-----------------------------------------------------------------------------------------
Samples collected in the current adjustment cycle:
  [Sample 1-5]       : 317.3m



#show rsvp trunk auto-bandwidth detail
Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2204, Egress: 100.1.1.3
-----------------------------------------------------------------------------------------
Sample Interval                         : 1 minutes
Adjustment Interval                     : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth                : 200m
Minimum Bandwidth                       : 100m
Maximum Bandwidth                       : 500m
Overflow Threshold Bandwidth            : 40m
Underflow Threshold Bandwidth           : 30m
Overflow Threshold Activate Bandwidth   : 0
Underflow Threshold Activate Bandwidth  : 0
Overflow Limit                          : 2
Underflow Limit                         : 2
Max. Bandwidth Exceed Limit             : 2
-----------------------------------------------------------------------------------------
Max-BW-exceed-limit action              : teardown
Resignal-failure-action                 : notify
Monitor Bandwidth                       : No
-----------------------------------------------------------------------------------------
Minimum Average Bandwidth               : 0
Maximum Average Bandwidth               : 0
Total Overflow Count                    : 0
Consecutive Overflow Count              : 0
Consecutive Eligible Overflow Count     : 0
Total Underflow Count                   : 0
Consecutive Underflow Count             : 0
Consecutive Eligible Underflow Count    : 0
```

```
Max. Bandwidth Exceed Count               : 0
Teardown Count                            : 0
-----------------------------------------------------------------------------------------
Last Bandwidth                            : 377.2m
Last Requested Bandwidth                  : 317.3m
Last Signaled Bandwidth                   : 317.3m
Current Bandwidth                         : 317.3m
Highest Bandwidth                         : 377.2m
-----------------------------------------------------------------------------------------
Time for Next Sample request              : 56 seconds
Time for Next Adjustment                  : 2 minutes, 46 seconds
Time of Last Bandwidth Request            : 2024 Jun 25 10:32:55
Time of Last Bandwidth Signal             : 2024 Jun 25 10:32:55
Time of Last Adjustment                   : 2024 Jun 25 10:32:55
Time of Highest Bandwidth Marked          : 2024 Jun 25 10:30:42
-----------------------------------------------------------------------------------------
Total Auto-Bandwidth Adjustments          : 6
Successful Adjustments                    : 6
Failed Adjustments                        : 0
-----------------------------------------------------------------------------------------
Samples collected in the current adjustment cycle:
```

Scenario 2 :

Configure the Auto bandwidth Profile without configuring any underflow-limit. When all the samples in adjustment cycle receive with the underflow rate, then only underflow bandwidth adjustment will happen.

Below Example shows underflow limit as a Zero and current bandwidth is set to 8.5g and all the samples are received less then underflow-limit. So, the Bandwidth adjustment happens only after adjustment cycle.

```
#show rsvp trunk auto-bandwidth PE1-PE2
Session: PE1-PE2-Primary, Tunnel-id: 5002, LSP-ID: 2202, Egress: 100.1.1.3
-----------------------------------------------------------------------------------------
Sample Interval                           : 1 minutes
Adjustment Interval                       : 5 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth                  : 4g
Minimum Bandwidth                         : 1g
Maximum Bandwidth                         : 9g
Overflow Threshold Bandwidth              : 10% (851.2m)
Underflow Threshold Bandwidth             : 10% (851.2m)
Overflow Threshold Activate Bandwidth     : 0
Underflow Threshold Activate Bandwidth    : 0
Overflow Limit                            : 1
Underflow Limit                           : 0
Max. Bandwidth Exceed Limit               : 1
-----------------------------------------------------------------------------------------
Max-BW-exceed-limit action                : notify
Resignal-failure-action                   : notify
Monitor Bandwidth                         : No
-----------------------------------------------------------------------------------------
Minimum Average Bandwidth                 : 6.5g
Maximum Average Bandwidth                 : 0
```

```
Total Overflow Count                       : 0
Consecutive Overflow Count                 : 0
Consecutive Eligible Overflow Count        : 0
Total Underflow Count                      : 5
Consecutive Underflow Count                : 5
Consecutive Eligible Underflow Count       : 5
Max. Bandwidth Exceed Count                : 0
Teardown Count                             : 0
-----------------------------------------------------------------------------------------
Last Bandwidth                             : 6.2g
Last Requested Bandwidth                   : 8.5g
Last Signaled Bandwidth                    : 8.5g
Current Bandwidth                          : 8.5g
Highest Bandwidth                          : 8.6g
-----------------------------------------------------------------------------------------
Time for Next Sample request               : 17 seconds
Time for Next Adjustment                   : 0 seconds
Time of Last Bandwidth Request             : 2024 Jun 25 11:30:42
Time of Last Bandwidth Signal               : 2024 Jun 25 11:30:42
Time of Last Adjustment                    : 2024 Jun 25 11:30:42
Time of Highest Bandwidth Marked           :2024 Jun 25 11:24:35
-----------------------------------------------------------------------------------------
Total Auto-Bandwidth Adjustments           : 11
Successful Adjustments                     : 11
Failed Adjustments                         : 0
-----------------------------------------------------------------------------------------
Samples collected in the current adjustment cycle:
  [Sample 1-5]       : 6.5g     6.3g     6.4g     6.4g     6.4g

#show rsvp trunk auto-bandwidth
--------------------+--------+--------+--------+----------+----------+----------+------
----+------------+--------------------
Trunk-Name          Trunk    LSP     Last     Requested  Signaled   Current    Highest
Adjust-Time  Last-Adjust
                    ID       ID       BW       BW         BW         BW         BW
Left(sec)    Time
--------------------+--------+--------+--------+----------+----------+----------+------
----+------------+--------------------
PE1-PE2                 5002    2202    8.5g    6.5g      6.5g      6.5g      8.6g
277          2024 Jun 25 11:30:42
```

Configure RSVP Auto Bandwidth on Boot on PE1 Router

1. Create auto-bandwidth Profile.

```
(config)#router rsvp
```

2. Configure Auto bandwidth on boot and set the values for sample interval, Adjust interval and Adjust interval count.

```
(config-router)#auto-bandwidth-on-boot 1 5 1
(config-router)#commit
```

Validation

Verify auto bandwidth on boot adjustments information as below:

```
#show running-config rsvp
!
router rsvp
 auto-bandwidth-on-boot 1 5 1
!
!
!
!
!
!
!
#
#show rsvp trunk auto-bandwidth

*** On boot auto bandwidth is in progress for 2 minutes, 3 seconds ***
--------------------+--------+--------+--------+----------+----------+----------+------
----+------------+-------------------
Trunk-Name          Trunk    LSP      Last     Requested  Signaled   Current    Highest
Adjust-Time  Last-Adjust
                    ID       ID       BW       BW         BW         BW         BW
Left(sec)    Time
--------------------+--------+--------+--------+----------+----------+----------+------
----+------------+-------------------

PE-1_to_PE-2_1     5002     2202     0        0          0          200m       144.6m
NA           NA
```

Commands for RSVP Auto-Bandwidth

The RSVP auto-bandwidth uses the following configuration commands.

rsvp-auto-bandwidth

Use this command to configure an auto bandwidth profile. The profile will have default settings if any parameter not configured explicitly. User can configure parameters to their need within auto bandwidth profile.

Use `no` parameter of this command to delete auto bandwidth profile.

Command Syntax

```
rsvp-auto-bandwidth PROFILENAME
no rsvp-auto-bandwidth PROFILENAME
```

Parameters

`<PROFILE_NAME>`	Specifies the name assigned to the auto-bandwidth profile during configuration. The profile name can be a maximum of 64 characters in length.

Default

None

Command Mode

Config mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure an auto-bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#commit
(config-auto-bandwidth)#exit
(config)#
```

The following example describes how to delete the auto bandwidth profile:

```
#configure terminal
(config)#no rsvp-auto-bandwidth bwp
(config)#commit
```

sample-interval

Use this command to configure a sample interval value in minutes on the auto bandwidth profile. Sample interval determines the frequency at which rate samples collected from associated trunks. Sample interval must not be configured more than adjust interval as no samples can be collected within an adjustment cycle in such case.

Note: Sample interval timers run per auto bandwidth profile and not per associated trunks. So, in case of bandwidth adjustments on trunks before adjustment cycle completion will leave the newly formed session with less number of samples in the remaining part of adjustment cycle. In order to avoid very few samples being processed, minimum-samples command shall be configured in absolute or percentage format.

Use the `no` parameter to remove the sample interval configuration.

Command Syntax

```
sample-interval <1 - 10080>
no sample-interval
```

Parameters

<1-10080>	Specifies the sample interval value in minutes.

Default

5 minutes

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure sample interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#sample-interval 2
(config-auto-bandwidth)#commit
```

The following example describes how to remove configured sample interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no sample-interval
(config-auto-bandwidth)#commit
```

adjust-interval

Use this command to configure a adjust interval value in minutes on the auto bandwidth profile. Adjust interval determines the duration of the adjustment cycle. Bandwidth update decisions for active session of associated trunks are taken after every adjustment cycle. Adjust interval must not be configured less than sample interval as no samples can be collected within an adjustment cycle in such case.

Note: Adjust interval timers run per auto bandwidth profile and not per associated trunks. So, in case of bandwidth adjustments on trunks before adjustment cycle completion will leave the newly formed session with less number of samples in the remaining part of adjustment cycle. In order to avoid very few samples being processed, minimum-samples command shall be configured in absolute or percentage format.

Use the `no` parameter to remove the adjust interval configuration.

Command Syntax

```
adjust-interval <5 - 10080>
no adjust-interval
```

Parameters

`<5-10080>`	Specifies the adjust interval value in minutes.

Default

30 minutes

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure adjust interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#adjust-interval 60
(config-auto-bandwidth)#commit
```

The following example describes how to remove configured adjust interval in the auto bandwidth profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no adjust-interval
(config-auto-bandwidth)#commit
```

minimum-bandwidth

Use this command to configure minimum bandwidth on the auto bandwidth profile. Even when traffic flow is much lesser than minimum bandwidth, LSP will be reserved with the configured minimum bandwidth during bandwidth adjustment process. When auto bandwidth profile associated with trunk, LSP will be signaled with minimum bandwidth when initial bandwidth is not configured in the profile.

Use the `no` parameter to remove the minimum bandwidth configuration from the profile.

Command Syntax

```
minimum-bandwidth BANDWIDTH
no minimum-bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure minimum bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#minimum-bandwidth 100m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the minimum bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no minimum-bandwidth
(config-auto-bandwidth)#commit
```

maximum-bandwidth

Use this command to configure maximum bandwidth on the auto bandwidth profile. Even when traffic flow is much higher than maximum bandwidth, LSP will be reserved with the configured maximum bandwidth during bandwidth adjustment process. Operator notification is generated if the traffic rate samples collected are higher than the maximum bandwidth but the reservation is limited to maximum bandwidth.

Note: When maximum bandwidth is configured, even a single traffic rate sample crossing the maximum bandwidth will trigger an MBB with maximum bandwidth reserved. If user doesn't wish to trigger an MBB for single sample of maximum bandwidth exceed, maximum-bandwidth-exceed-limit shall be configured with a value to mention the number of consecutive samples to cross maximum bandwidth to take further action.

Use the `no` parameter to remove the maximum bandwidth configuration from the profile.

Command Syntax

```
maximum-bandwidth BANDWIDTH
no maximum-bandwidth
```

Parameters

`BANDWIDTH`	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure maximum bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#maximum-bandwidth 900m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the maximum bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no maximum-bandwidth
(config-auto-bandwidth)#commit
```

initial-bandwidth

Use this command to configure initial bandwidth on the auto bandwidth profile. When auto bandwidth profile associated with trunk, LSP will be signalled with initial bandwidth when initial bandwidth is configured in the profile. For trunks which are already associated with auto bandwidth profile and the system going through reload, initial bandwidth will not be applicable as on boot computation will trigger to update active sessions with bandwidth as per the on boot period traffic rate sample computation.

Use the `no` parameter to remove the initial bandwidth configuration from the profile.

Command Syntax

```
initial-bandwidth BANDWIDTH
no initial-bandwidth
```

Parameters

BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure initial bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#initial-bandwidth 500m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the initial bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no initial-bandwidth
(config-auto-bandwidth)#commit
```

underflow-threshold

Use this command to configure underflow threshold in percentage or absolute value format on the auto bandwidth profile. Underflow threshold sets the amount of reduction in traffic rate sample to detect an eligible underflow. As an example, absolute underflow threshold 10m when current bandwidth is 200m means, a traffic rate sample of 190.1m will not be considered eligible underflow sample and a sample of 189.9m will be considered eligible underflow sample.

When all the traffic rate samples collected for an auto bandwidth profile associated trunk cross underflow threshold in an adjustment cycle, then the highest eligible traffic rate sample will be considered to re-signal the session with new bandwidth at the end of an adjustment cycle.

Constraints like underflow-limit and underflow-threshold-activate-bandwidth will add additional logic on how bandwidth update action is taken. This will be discussed in respective sections.

If underflow threshold is not configured, then minor reduction in traffic rate sample also will be considered as eligible underflow bandwidth sample. So, underflow and overflow threshold is a recommended configuration even though it is not mandatory.

When underflow threshold is configured in percentage, the threshold will be computed based on the current bandwidth and the percentage value. Example, underflow threshold 10% for a current bandwidth of 100m means a sample of 90m or lesser will be considered eligible underflow sample. Underflow threshold can be configured either as absolute value or in percentage but not both.

Use the `no` parameter to remove the underflow bandwidth configuration from the profile.

Command Syntax

```
underflow-threshold (percent <1-100>) | (absolute BANDWIDTH)
no underflow-threshold (percent | absolute)
```

Parameters

`<1-100>`	Specifies the underflow threshold value in percentage.
`BANDWIDTH`	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow bandwidth in percentage format in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#underflow-threshold percent 10
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no underflow-threshold percent
(config-auto-bandwidth)#commit
```

overflow-threshold

Use this command to configure overflow threshold in percentage or absolute value format on the auto bandwidth profile. Overflow threshold sets the amount of increase in traffic rate sample required to detect an eligible overflow. As an example, absolute overflow threshold 10m when current bandwidth is 200m means, a traffic rate sample of 209.9m will not be considered eligible overflow sample and a sample of 210.1m will be considered eligible overflow sample.

When a traffic rate sample collected for an auto bandwidth profile associated trunk crosses overflow threshold in an adjustment cycle, then the highest eligible traffic rate sample will be considered to re-signal the session with new bandwidth at the end of adjustment cycle.

Constraints like overflow-limit and overflow-threshold-activate-bandwidth will add additional logic on how bandwidth update action is taken. This will be discussed in respective sections.

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If overflow threshold is not configured, then minor increase in traffic rate sample also will be considered as eligible overflow bandwidth sample. So, underflow and overflow threshold is a recommended configuration even though it is not mandatory.

When overflow threshold is configured in percentage, the threshold will be computed based on the current bandwidth and the percentage value. Example, overflow threshold 10% for a current bandwidth of 100m means a sample of 110m or more will be considered eligible overflow sample. Overflow threshold can be configured either as absolute value or in percentage but not both.

Use the `no` parameter to remove the underflow bandwidth configuration from the profile.

Command Syntax

```
overflow-threshold (percent <1-100>) | (absolute BANDWIDTH)
no overflow-threshold (percent | absolute)
```

Parameters

<1-100>	Specifies the overflow threshold value in percentage.
BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow bandwidth in absolute format in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#overflow-threshold absolute 10m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no overflow-threshold absolute
(config-auto-bandwidth)#commit
```

underflow-threshold-activate-bandwidth

Use this command to configure absolute bandwidth range to allow bandwidth re-signalling when underflow threshold and underflow limit criteria matched. This configuration helps to limit the underflow bandwidth reservation update for certain range of bandwidth.

As an example, if the current bandwidth is 500m and the underflow threshold is 10%. So, normally, if all traffic rate samples collected are in the range of 400m to 450m, session will be re-signalled to reserve new bandwidth. However, if underflow-threshold-activate-bandwidth is configured as 300m, then the traffic rate samples in the range of 400m to

450m will not trigger bandwidth update. Only when the traffic rate samples are less than 300m, then it will be considered as eligible sample.

The configuration creates an absolute bandwidth range for underflow samples to be eligible. The bandwidth range for underflow eligibility will be minimum bandwidth (or zero when minimum bandwidth is not configured) to underflow-threshold-activate-bandwidth value. When this command is not configured, there won't be any such absolute range and only underflow-threshold and underflow-limit will be considered for computation, if configured.

Use the `no` parameter to remove the underflow threshold activate bandwidth configuration from the profile.

Command Syntax

```
underflow-threshold-activate-bandwidth BANDWIDTH
no underflow-threshold-activate-bandwidth
```

Parameters

`BANDWIDTH`	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow threshold activate bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#underflow-threshold-activate-bandwidth 500m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow threshold activate bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no underflow-threshold-activate-bandwidth
(config-auto-bandwidth)#commit
```

overflow-threshold-activate-bandwidth

Use this command to configure absolute bandwidth range to allow bandwidth re-signalling when overflow threshold and overflow limit criteria matched. This configuration helps to limit the overflow bandwidth reservation update for certain range of bandwidth.

As an example, if the current bandwidth is 100m and the overflow threshold is 10%. Normally, if a traffic rate sample collected is in the range of 110m to 150m, session will be re-signalled to reserve new bandwidth. However, if overflow-threshold-activate-bandwidth is configured as 300m, then the traffic rate samples in the range of 110m to 150m will not trigger bandwidth update. Only when the traffic rate samples are more than 300m, then it will be considered as eligible sample.

The configuration creates an absolute bandwidth range for overflow samples to be eligible. The bandwidth range for overflow eligibility will be overflow-threshold-activate-bandwidth value to a practical infinity. When this command is not configured, there won't be any such absolute range and only overflow-threshold and overflow-limit will be considered for computation, if configured.

Use the `no` parameter to remove the overflow threshold activate bandwidth configuration from the profile.

Command Syntax

```
overflow-threshold-activate-bandwidth BANDWIDTH
no overflow-threshold-activate-bandwidth
```

Parameters

`BANDWIDTH`	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure overflow threshold activate bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#overflow-threshold-activate-bandwidth 500m
(config-auto-bandwidth)#commit
```

The following example describes how to remove the overflow threshold activate bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no overflow-threshold-activate-bandwidth
(config-auto-bandwidth)#commit
```

underflow-limit

Use this command to configure underflow limit on the auto bandwidth profile. When underflow limit is configured, if the traffic rate samples collected on the associated session consecutively crosses underflow threshold for underflow limit times, then the bandwidth adjustment will be triggered immediately without waiting for adjustment cycle completion. When underflow-threshold-activate-bandwidth is configured, even this criteria is considered to mark a sample as eligible underflow sample.

Only when underflow limit is configured, underflow adjustment may happen before the completion of adjustment cycle. Otherwise, underflow adjustment considered only at the completion of adjustment cycle when all samples found to be eligible underflow sample.

Use the `no` parameter to remove the underflow limit configuration from the profile.

Command Syntax

```
underflow-limit <1-10080>
no underflow-limit
```

Parameters

<1-10080>	Specifies the underflow limit value for consecutive eligible samples.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure underflow limit in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#underflow-limit 3
(config-auto-bandwidth)#commit
```

The following example describes how to remove the underflow limit configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no underflow-limit
(config-auto-bandwidth)#commit
```

overflow-limit

Use this command to configure overflow limit on the auto bandwidth profile. When overflow limit is configured, if the traffic rate samples collected on the associated session consecutively crosses overflow threshold for overflow limit times, then the bandwidth adjustment will be triggered immediately without waiting for adjustment cycle completion. When overflow-threshold-activate-bandwidth is configured, even this criteria is considered to mark a sample as eligible underflow sample.

Only when overflow limit is configured, overflow adjustment may happen before the completion of adjustment cycle. Otherwise, overflow adjustment considered only at the completion of adjustment cycle when a sample found to be eligible overflow sample.

If the traffic rate sample crosses maximum bandwidth, then maximum-bandwidth-exceed-limit configuration comes into picture and by default, a single sample crossing maximum bandwidth triggers bandwidth update. This situation is different from overflow scenario.

Use the `no` parameter to remove the overflow limit configuration from the profile.

Command Syntax

```
overflow-limit <1-10080>
no overflow-limit
```

Parameters

`<1-10080>`	Specifies the overflow limit value for consecutive eligible samples.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure overflow limit in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#overflow-limit 3
(config-auto-bandwidth)#commit
```

The following example describes how to remove the overflow limit configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no overflow-limit
(config-auto-bandwidth)#commit
```

maximum-bandwidth-exceed-limit

Use this command to configure maximum bandwidth exceed limit on the auto bandwidth profile. When maximum bandwidth exceed limit is configured, if the traffic rate samples collected on the associated session consecutively crosses maximum bandwidth for maximum-bandwidth-exceed-limit times, then the action will be triggered immediately without waiting for adjustment cycle completion. When maximum-bandwidth-exceed-limit is not configured, a single sample exceeding maximum bandwidth will trigger an action which is re-signal with updated bandwidth or restart the session with initial or minimum bandwidth based on the action configured.

When maximum bandwidth is not configured, maximum bandwidth exceed limit configuration doesn't have any significance. Overflow limit and maximum bandwidth exceed limits are independent commands with different significance with latter associated with maximum bandwidth.

Use the `no` parameter to remove the maximum bandwidth exceed limit configuration from the profile.

Command Syntax

```
maximum-bandwidth-exceed-limit <1-10080>
no maximum-bandwidth-exceed-limit
```

Parameters

`<1-10080>`	Specifies the maximum bandwidth exceed limit value for consecutive eligible samples.

Default

1

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure maximum bandwidth exceed limit in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#maximum-bandwidth-exceed-limit 2
(config-auto-bandwidth)#commit
```

The following example describes how to remove the maximum bandwidth exceed limit configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no maximum-bandwidth-exceed-limit
(config-auto-bandwidth)#commit
```

maximum-bandwidth-exceed-action

Use this command to configure maximum bandwidth exceed action on the auto bandwidth profile. When the traffic rate samples collected on the associated session consecutively crosses maximum bandwidth for maximum-bandwidth-exceed-limit times (or one time if limit is not configured), then the action to be triggered will be decided by this configuration. If not configured, default action is to re-signal the session with maximum bandwidth or ignore if session is already signalled with maximum bandwidth. In any case, user will be notified about the maximum bandwidth being exceeded. However, with exceed action configured as teardown, session will be released and restarted with initial bandwidth or minimum bandwidth if initial bandwidth is not configured.

This action will lead to service interruption if there are no alternate transport. So, this configuration is recommended to be used with full awareness of the impact.

Use the `no` parameter to remove the maximum bandwidth exceed action configuration from the profile.

Command Syntax

```
maximum-bandwidth-exceed-action (teardown)
no maximum-bandwidth-exceed-action
```

Parameters

`teardown`	Teardown the session exceeding maximum bandwidth.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure maximum bandwidth exceed action in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#maximum-bandwidth-exceed-action teardown
(config-auto-bandwidth)#commit
```

The following example describes how to remove the maximum bandwidth exceed action configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no maximum-bandwidth-exceed-action
(config-auto-bandwidth)#commit
```

resignal-failure-action

Use this command to configure an action on the auto bandwidth profile when the bandwidth update re-signalling fails on the associated session. By default, if re-signalling fails (3 attempts) for the updated bandwidth, it will be noted down as re-signalling failure and session will continue with its current bandwidth reservation. If severe actions to be taken on such re-signal failure, then teardown action can be configured which will release the current session and restart freshly with initial bandwidth or minimum bandwidth when initial bandwidth is not configured.

This action will lead to service interruption if there are no alternate transport. So, this configuration is recommended to be used with full awareness of the impact.

Use the `no` parameter to remove the re-signal failure action configuration from the profile.

Command Syntax

```
resignal-failure-action (teardown)
no resignal-failure-action
```

Parameters

`teardown`	Specifies the teardown the session when re-signalling with new bandwidth fails.

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure re-signal failure action in a profile:

```
#configure terminal
```

```
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#resignal-failure-action teardown
(config-auto-bandwidth)#commit
```

The following example describes how to remove the re-signal failure action configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no resignal-failure-action
(config-auto-bandwidth)#commit
```

sync-bandwidth

Use this command to configure bandwidth synchronization for primary and secondary sessions of an auto bandwidth profile associated trunk. With this configuration, in case the associated trunk is configured with primary and secondary sessions, every time primary session goes through a bandwidth update, secondary session also will be re-signalled with primary session's bandwidth. Thus, secondary path is determined with proper reservation constraints to ensure it is in the correct bandwidth reserved state when traffic switches to secondary.

Use the `no` parameter to remove synchronise bandwidth configuration from the profile.

Command Syntax

```
sync-bandwidth
no sync-bandwidth
```

Parameters

None

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure synchronize bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#sync-bandwidth
(config-auto-bandwidth)#commit
```

The following example describes how to remove the synchronise bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no sync-bandwidth
(config-auto-bandwidth)#commit
```

monitor-bandwidth

Use this command to configure only monitor the traffic rate samples and computation without taking any action. This command can be used to monitor the traffic behaviour without updating the active sessions. With this configuration, in case of overflow, underflow, adjustment cycle completion time computation results, maximum bandwidth exceed, etc., notification is provided without taking any action.

Use the `no` parameter to remove monitor bandwidth configuration from the profile.

Command Syntax

```
monitor-bandwidth
no monitor-bandwidth
```

Parameters

None

Default

None

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure monitor bandwidth in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#monitor-bandwidth
(config-auto-bandwidth)#commit
```

The following example describes how to remove the monitor bandwidth configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no monitor-bandwidth
(config-auto-bandwidth)#commit
```

minimum-samples

Use this command to configure the minimum samples required in an adjustment cycle for bandwidth processing. Sample timers and Adjust timers are executed per auto bandwidth profile and not per associated trunk. Thus, there are scenarios of a trunk going through a bandwidth update few minutes ago and again ends up with adjustment cycle completion processing with very few samples collected. In order to avoid such scenarios, minimum samples required in an adjustment cycle to process the bandwidth shall be configured.

Configuration is accepted in both absolute and in percentage format. This gives user the flexibility to choose the format that suites their need. If sample interval and adjust interval expected to be fixed, then absolute configuration helps providing the requirement of exact number of minimum samples required to process. If exact number isn't important and there are chances of changing adjust interval or sample interval in future, then percentage format can be chosen. However, only one of the formats can be configured.

By default, even if there is one traffic rate sample during adjustment cycle completion, bandwidth will be processed. So, it will be recommended to have this configuration if users are keen on minimum of certain samples to be considered for bandwidth computation.

Use the `no` parameter to remove the minimum sample configuration from the profile.

Command Syntax

```
minimum-samples (percent <1-100>) | (absolute <1-10080>)
no underflow-limit (percent | absolute)
```

Parameters

<1-10080>	Specifies the absolute value for minimum samples required in an adjustment cycle.
<1-100>	Specifies the minimum sample percentage required in an adjustment cycle.

Default

1 sample

Command Mode

Auto bandwidth mode

Applicability

Introduced in OcNOS version 6.5.2.

Example

The following example describes how to configure minimum samples in percentage format in a profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#minimum-samples percent 70
(config-auto-bandwidth)#commit
```

The following example describes how to remove the minimum samples configuration from the profile:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#no minimum-samples percent
(config-auto-bandwidth)#commit
```

auto-bandwidth

Use this command to attach an auto bandwidth profile to a trunk. When the auto bandwidth profile is attached to the trunk, active session will be re-signalled with initial bandwidth configured in the auto bandwidth profile or minimum bandwidth configured if initial bandwidth is not configured. Bandwidth update will be triggered only if there is variation in the bandwidth to be initialized. Attaching or detaching an auto bandwidth profile doesn't trigger any session flap and doesn't cause traffic impact.

When an auto bandwidth profile is associated with first trunk, sample interval and adjust interval timers will start and are stopped when the profile is removed from the last trunk.

Manual bandwidth configuration for the sessions and auto bandwidth profile attach are mutually exclusive and the configuring both of them on a trunk is not allowed.

Use the `no` parameter to remove the auto bandwidth profile from the trunk.

Command Syntax

```
auto-bandwidth PROFILENAME
no auto-bandwidth PROFILENAME
```

Parameters

PROFILENAME	Specifies the name of the auto bandwidth profile.

Default

None

Command Mode

Trunk mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to associate an auto bandwidth profile to a trunk:

```
#configure terminal
(config)#rsvp-auto-bandwidth bwp
(config-auto-bandwidth)#exit
(config)#rsvp-trunk t1
(config-trunk)#auto-bandwidth bwp
(config-trunk)#commit
```

The following example describes how to remove the auto bandwidth profile from the trunk:

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#no auto-bandwidth bwp
(config-trunk)#commit
```

auto-bandwidth-on-boot

Use this command to configure on boot sample interval, adjust interval and number of adjustment cycles. When the system is reloaded and comes up, all active sessions of trunks associated with auto bandwidth profiles run a relatively faster adjustment cycle with quicker sample collection to settle the sessions with accurate bandwidth reservation.

By default, sample interval is 1 minute, adjust interval is 5 minutes and the adjustment cycle runs one time. After the adjustment cycle completion, samples of each associated trunks computed to re-signal the sessions with updated bandwidth. Then the auto bandwidth profile based adjustment cycle starts. If user wishes to run the boot up time rigorous sample computation for longer duration or multiple rounds, then it shall be configured. The configurations will apply from system reload if the configuration is saved. Properties of auto bandwidth profiles will not be applied during boot up time computation.

Use the `no` parameter to remove the auto bandwidth profile from the trunk.

Command Syntax

```
auto-bandwidth-on-boot <1-10080> <1-10080> <1-10>
no auto-bandwidth-on-boot
```

Parameters

<1-10080>	On boot sample interval value in minutes.
<1-10080>	On boot adjustment interval value in minutes.
<1-10>	Specifies the number of adjustment cycles to run on boot.

Default

Sample interval 1 minute, adjust interval 5 minutes and 1 adjustment cycle.

Command Mode

Router mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to configure on boot auto bandwidth parameters:

```
#configure terminal
(config)#router rsvp
(config-router)#auto-bandwidth-on-boot 1 10 3
(config-router)#commit
```

The following example describes how to reset on boot auto bandwidth parameters:

```
#configure terminal
(config)#router rsvp
(config-router)#no auto-bandwidth-on-boot
(config-router)#commit
```

force-auto-bandwidth-adjustment

Use this command to force a bandwidth adjustment on a trunk associated with auto bandwidth profile. When the command is executed without bandwidth value mentioned, traffic rate samples collected till the time are used to compute the bandwidth to be adjusted. In case of bandwidth value mentioned in the command, the bandwidth is verified for eligibility and bandwidth update will be triggered.

Command Syntax

```
rsvp-trunk TRUNKNAME force-auto-bandwidth-adjustment (BANDWIDTH|)
```

Parameters

TRUNKNAME	Specifies the name of the trunk to go through forced bandwidth adjustment.
BANDWIDTH	Specifies the bandwidth value in the range of 1k to 999g.

Default

None

Command Mode

Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how you can force a bandwidth adjustment for a trunk with an auto bandwidth profile:

```
#rsvp-trunk t1 force-auto-bandwidth-adjustment
```

clear rsvp auto-bandwidth

Use this command to reset the auto bandwidth adjustment cycle by clearing all the traffic samples collected by the associated trunks and by restarting sample and adjust timers. If auto bandwidth profile name is not mentioned, then all trunks associated with any auto bandwidth profile will be reset and computation will start freshly.

Command Syntax

```
clear rsvp auto-bandwidth (PROFILENAME|)
```

Parameters

PROFILENAME	Specifies the name of the auto bandwidth profile.

Default

None

Command Mode

Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to restart processing of an auto bandwidth profile:

```
#clear rsvp auto-bandwidth bwp
```

clear rsvp trunk auto-bandwidth-statistics

Use this command to clear the statistics maintained on a trunk associated with auto bandwidth profile. Statistics will be mainly the highest watermarked bandwidth, last adjusted bandwidth, how many times adjustment triggered, status of the adjustment trigger, etc. This command will only clear the auto bandwidth statistics for the trunk and doesn't impact the operation of auto bandwidth including the traffic rate samples collected for the current adjustment cycle.

Command Syntax

```
clear rsvp trunk TRUNKNAME auto-bandwidth-statistics
```

Parameters

TRUNKNAME	Specifies the name of the trunk associated with auto bandwidth profile.

Default

None

Command Mode

Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example describes how to clear the auto bandwidth statistics on a trunk which is associated with the auto bandwidth profile:

```
#clear rsvp trunk t1 auto-bandwidth-statistics
```

Show Commands for RSVP

show rsvp auto-bandwidth

Use this command to display auto bandwidth profile specific information.

Command Syntax

```
show rsvp auto-bandwidth
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing all the auto bandwidth profiles:

```
 #show rsvp auto-bandwidth

Profile Name : bwp
-----------------------------------------------------------------------------
Sample Interval                               : 5 minutes (due in 4 minutes)
Adjust Interval                               : 30 minutes (due in 29 minutes)
Minimum Samples required for processing      : 1
Initial Bandwidth                             : 0
Minimum bandwidth                             : 0
Maximum bandwidth                             : 100m
Underflow Threshold Bandwidth                 : 5m
```

```
Overflow Threshold Bandwidth                  : 5m
Underflow Threshold Activate Bandwidth        : 0
Overflow Threshold Activate Bandwidth         : 0
Overflow Limit                                : 3
Underflow Limit                               : 3
Maximum Bandwidth Exceed Limit                : 1
Maximum Bandwidth Exceed Action               : notify
Re-signal Failure Action                      : notify
Sync Bandwidth                                : No
Monitor Bandwidth                             : No
No. of trunks associated                      : 1
```

show rsvp auto-bandwidth detail

Use this command to display a specific auto bandwidth profile information or all auto bandwidth profile information along with associated trunk details.

Command Syntax

```
show rsvp auto-bandwidth (PROFILENAME | detail)
```

Parameters

PROFILENAME	Specifies the name of the auto bandwidth profile.
detail	Specifies detailed information of all the auto bandwidth profiles.

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example is for viewing all the auto bandwidth profiles along with associated trunks:

```
#show rsvp auto-bandwidth detail

Profile Name : bwp
-----------------------------------------------------------------------------
Sample Interval                           : 5 minutes (due in 4 minutes)
Adjust Interval                           : 30 minutes (due in 29 minutes)
Minimum Samples required for processing   : 1
Initial Bandwidth                         : 0
Minimum bandwidth                         : 0
Maximum bandwidth                         : 100m
Underflow Threshold Bandwidth             : 5m
Overflow Threshold Bandwidth              : 5m
Underflow Threshold Activate Bandwidth    : 0
Overflow Threshold Activate Bandwidth     : 0
Overflow Limit                            : 3
Underflow Limit                           : 3
Maximum Bandwidth Exceed Limit            : 1
Maximum Bandwidth Exceed Action           : notify
Re-signal Failure Action                  : notify
Sync Bandwidth                            : No
Monitor Bandwidth                         : No
```

```
No. of trunks associated                 : 1
------------+--------+--------+--------+----------+----------+----------+----------+-----------
Trunk-Name   Trunk    LSP      Last     Requested  Signaled   Current    Highest    LastAdjust
            ID       ID       BW       BW         BW         BW         Time                  -
-----------+--------+--------+--------+----------+----------+----------+----------+-----------
t1           5001     2201     10.1m    22.5m      22.5m      22.5m      35.5m      2024 Jul 23
```

show rsvp trunk auto-bandwidth

Use this command to display the information of all the trunks associated with the auto bandwidth profile. This show command will display high level information like what is the last bandwidth, current bandwidth, last adjustment time, time left in adjustment cycle in seconds, etc.

Command Syntax

```
show rsvp trunk auto-bandwidth
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing an auto bandwidth summary of all the trunks associated with auto bandwidth profile:

```
      #show rsvp trunk auto-bandwidth
-----------+------+-----+------+----------+---------+--------+--------+------------+-----------
Trunk-Name  Trunk  LSP   Last   Requested  Signaled  Current  Highest  Adjust-Time  Last-Adjust
           ID     ID    BW     BW         BW        BW       BW       Left(sec)    Time
-----------+------+-----+------+----------+---------+--------+--------+------------+-----------
t1          5001   2201  10.1m  22.5m      22.5m     22.5m    35.5m    1142         2024 Jul 23
```

show rsvp trunk auto-bandwidth detail

Use this command to display the information of a trunk or all the trunks associated with the auto bandwidth profile. This command will provide detailed information of the auto bandwidth related statistics on the trunk as well as details of traffic rate samples collected in an adjust cycle and the time left for next sample collection, etc.

Command Syntax

```
show rsvp trunk auto-bandwidth (TRUNKNAME | detail)
```

Parameters

`TRUNKNAME`	Specifies the name of the particular trunk to display auto-bandwidth details for.

Command Mode

Exec mode and Privileged Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

Example for viewing the auto bandwidth details of all the trunks associated with auto bandwidth profile

```
#show rsvp trunk auto-bandwidth detail
:Session: t1-Primary, Tunnel-id: 5001, LSP-ID: 2201, Egress: 2.2.2.2
-----------------------------------------------------------------------------
Sample Interval                        : 5 minutes
Adjustment Interval                    : 30 minutes
Minimum Samples required for processing : 1
Initialization Bandwidth               : 0
Minimum Bandwidth                      : 0
Maximum Bandwidth                      : 100m
Overflow Threshold Bandwidth           : 5m
Underflow Threshold Bandwidth          : 5m
Overflow Threshold Activate Bandwidth  : 0
Underflow Threshold Activate Bandwidth : 0
Overflow Limit                         : 3
Underflow Limit                        : 3
Max. Bandwidth Exceed Limit            : N/A
-----------------------------------------------------------------------------
Max-BW-exceed-limit action             : notify
Resignal-failure-action                : notify
Monitor Bandwidth                      : No
-----------------------------------------------------------------------------
Minimum Average Bandwidth              : 0
Maximum Average Bandwidth              : 22.5m
Total Overflow Count                   : 1
Consecutive Overflow Count             : 1
Consecutive Eligible Overflow Count    : 1
Total Underflow Count                  : 0
Consecutive Underflow Count            : 0
Consecutive Eligible Underflow Count   : 0
Max. Bandwidth Exceed Count            : 0
Teardown Count                         : 0
-----------------------------------------------------------------------------
Last Bandwidth                         : 10.2m
Last Requested Bandwidth               : 15.6m
Last Signaled Bandwidth                : 15.6m
Current Bandwidth                      : 15.6m
Highest Bandwidth                      : 35.3m
-----------------------------------------------------------------------------
Time for Next Sample request           : 1 minutes, 20 seconds
Time for Next Adjustment               : 16 minutes, 30 seconds
Time of Last Bandwidth Request         : 2024 Jul 23 11:32:44
Time of Last Bandwidth Signal          : 2024 Jul 23 11:32:44
Time of Last Adjustment                : 2024 Jul 23 11:32:44
Time of Highest Bandwidth Marked       : 2024 Jul 23 11:14:37
-----------------------------------------------------------------------------
Total Auto-Bandwidth Adjustments       : 2
```

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```
Successful Adjustments                    : 2
Failed Adjustments                        : 0
-----------------------------------------------------------------------------
Samples collected in the current adjustment cycle:
  [Samples 1-5]      : 17.5m      18.3m      22.5m
```

RSVP-TE Command Reference

CHAPTER 1 RSVP-TE Commands

This chapter describes the RSVP-TE commands.

- neighbor X:X::X:X
- no cspf
- no igp-shortcut
- no loop-detection
- no php
- no record
- no refresh-path-parsing
- no refresh-resv-parsing
- path-option dynamic pce
- php
- primary ADMIN-GROUP-NAME
- primary affinity
- primary bandwidth
- primary cspf
- primary cspf-retry-limit
- primary cspf-retry-timer
- primary filter
- primary hold-priority
- primary hop-limit
- primary label-record
- primary local-protection
- no primary affinity
- no primary cspf
- no primary record
- primary path
- primary record
- primary retry-limit
- primary retry-timer
- primary reuse-route-record
- primary setup-priority
- primary traffic
- refresh-time
- refresh-path-parsing
- refresh-resv-parsing
- reoptimize
- restart rsvp graceful

- revert-timer
- router rsvp
- rsvp hello-interval
- rsvp hello-receipt
- rsvp hello-timeout
- rsvp keep-multiplier
- rsvp refresh-time
- rsvp-path
- rsvp-trunk
- rsvp-trunk force-reoptimize
- rsvp-trunk force-switchover-secondary
- rsvp-trunk-restart
- secondary ADMIN-GROUP-NAME
- secondary bandwidth
- secondary cspf
- secondary cspf-retry-limit
- secondary cspf-retry-timer
- secondary filter
- secondary hold-priority
- secondary hop-limit
- secondary label-record
- secondary local-protection
- no secondary affinity
- no secondary cspf
- no secondary record
- secondary path
- secondary-priority path
- secondary-priority hold-priority
- secondary-priority setup-priority
- secondary-priority label-record
- secondary-priority hop-limit
- secondary-priority bandwidth
- secondary record
- secondary retry-limit
- secondary retry-timer
- secondary reuse-route-record

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A.B.C.D

Use this command to configure an explicit IPv4 route sub-object as either loose or strict. A list of sub-objects specifies an explicit route to the egress router for an LSP.

- For the strict type of route addresses, the route taken from the previous router to the current router must be a directly connected path and a message exchanged between the two routers should not pass any intermediate routers. This ensures that routing is enforced on the basis of each link. For configuring path-option as “strict” path, we need to configure interface ip address (ip address of next-hop interface). strict with loopback ip shall not be configured.
- For the loose type of route addresses, the route taken form the previous router to the current router need not be a direct path and a message exchanged between the two routers can pass other routers.For configuring path-option as “loose” path, we can configure either loopback interface ip address or next-hop interface ip address. It will expand the explicit path accordingly since the next hop need not to be a connected one.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
A.B.C.D
A.B.C.D (loose|strict)
no A.B.C.D
no A.B.C.D (loose|strict)
```

Parameters

`loose`	Make this node loose
`strict`	Make this node strict

Default

By default, A.B.C.D is disabled

Command Mode

Path mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-path mypath
(config-path)#10.10.0.5 strict
```

ack-wait-timeout

Use this command to set the acknowledgement wait timeout for the RSVP daemon. This command can be invoked from config-router mode.

Use the `no` parameter with this command to revert to the default settings.

Command Syntax

```
ack-wait-timeout <1-65535>
no ack-wait-timeout
```

Parameters

`<1-65535>`	Configure acknowledgement wait timeout.

Default

By default, `no ack-wait-timeout`.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 4.2.

Examples

```
#configure terminal
(config)router rsvp
(config-router)# ack-wait-timeout 30

#configure terminal
(config)router rsvp
(config-router)# no ack-wait-timeout
```

clear rsvp session

Use this command to reset either all or specified sessions originating from a specific ingress and terminating on the specific egress.

Note: If the affected session originates from the router where the command is issued, it is stopped and started. If the affected session does not originate from the router where the command is issued, it is stopped and deleted.

Command Syntax

```
clear rsvp session TUNNEL-ID LSP-ID INGRESS EGRESS
```

Parameters

`TUNNELID`	Clear tunnel ID sessions
`LSP-ID`	Clear LSP ID sessions
`INGRESS`	Clear ingress sessions
`EGRESS`	Clear egress sessions

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear rsvp session 1 1 1.2.3.4 192.168.1.1
```

clear rsvp trunk

Use this command to clear an RSVP trunk or to clear all RSVP trunks.

Clearing a trunk also kills any session associated with the trunk. This command is useful when a trunk is missing required data such as routing information. When data is missing, the trunk is in an incomplete state, and clearing it correctly re-initializes the session.

Note: If this command is given in the session on the ingress router, the session stops and restarts. If this command is given in the session on the egress router, the session is not cleared.

Command Syntax

Note: Use the following commands to clear standard RSVP Trunks:

```
clear rsvp trunk *
clear rsvp trunk ingress (TRUNKNAME|*)
clear rsvp trunk non-ingress (TRUNKNAME|*)
clear rsvp trunk (TRUNKNAME|*)
clear rsvp trunk (TRUNKNAME|*) primary
clear rsvp trunk (TRUNKNAME|*) secondary
```

Parameters

`*`	Clear all RSVP trunks configured
`TRUNKNAME`	Name of a specific trunk to be cleared
`ingress`	Clear an RSVP ingress trunk
`non-ingress`	Clear an RSVP non-Ingress trunk
`primary`	Clear all primary sessions configured for this trunk
`secondary`	Clear all secondary sessions configured for this trunk

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#clear rsvp trunk mytrunk
#clear rsvp trunk *
#clear rsvp trunk ingress mytrunk
#clear rsvp trunk ingress *
#clear rsvp trunk non-ingress mytrunk
#clear rsvp trunk non-ingress *
#clear rsvp trunk mytrunk primary
#clear rsvp trunk * primary
#clear rsvp trunk mytrunk secondary
#clear rsvp trunk * secondary
```

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cspf

Use this command to enable the use of Constrained Shortest Path First (CSPF) server for all RSVP sessions. If CSPF is turned off globally, it cannot be enabled for any LSP.

The CSPF server computes paths for LSPs that are subject to various constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP but also the links. It attempts to minimize congestion by intelligently balancing the network load.

Use the no cspf command to disable this configuration.

Note: CSPF server information is not signaled across session and hence sessions in transit and egress nodes will not be aware of the CSPF server. So, in multi CSPF scenarios, neighbor down event from a CSPF server restart all sessions irrespective of which CSPF server sessions were using.

Note: The CSPF server is unaware of whether an interface is label-switching and RSVP enabled. So, the LSP calculation may include non-RSVP interfaces too, and may lead to tunnel sessions not coming up. To avoid links that are not label-switching and RSVP enabled, “te-metric” with the highest value shall be configured on those interfaces to de-prioritize those links in the TE database.

Command Syntax

```
cspf
```

Parameters

None

Default

By default, CSPF server is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Router mode to disable CSPF for all RSVP sessions.

```
#configure terminal
(config)#router rsvp
(config-router)#cspf
```

debug rsvp all

Use this command to enable all debugging options for an RSVP daemon.

Use the `no` parameter with this command to stop logging all debugging information.

Command Syntax

```
debug rsvp (all|)
no debug rsvp (all|)
```

Parameters

None

Command Mode

Privileged Exec mode and Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp all
```

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debug rsvp cspf

Use this command to enable the exchange of debugging messages between the RSVP module and the CSPF module.

Use the `no` parameter with this command to stop logging CSPF debugging information.

Command Syntax

```
debug rsvp cspf
no debug rsvp cspf
```

Parameters

None

Command Mode

Privileged Exec mode and Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp cspf
```

debug rsvp events

Use this command to enable debugging of events that were generated from an RSVP daemon.

Use the `no` parameter with this command to stop logging RSVP debugging information.

Command Syntax

```
debug rsvp events
no debug rsvp events
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp events
```

debug rsvp fsm

Use these commands to enable debugging of events related to RSVP finite state machines (FSM). Commands are available to log debugging information for the egress FSM, the ingress FSM, the transit FSM, the transit upstream FSM, or the transit downstream FSM.

Use the `no` parameter with these commands to stop logging FSM debugging information.

Command Syntax

```
debug rsvp fsm
debug rsvp fsm egress
debug rsvp fsm ingress
debug rsvp fsm transit
debug rsvp fsm transit upstream
debug rsvp fsm transit downstream
no debug rsvp fsm
no debug rsvp fsm egress
no debug rsvp fsm ingress
no debug rsvp fsm transit
no debug rsvp fsm transit upstream
no debug rsvp fsm transit downstream
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)#debug rsvp fsm transit upstream
```

debug rsvp hexdump

Use this command to enable the hexdump debugging option for an RSVP daemon.

Use the `no` parameter with this command to stop logging hexdump debugging information.

Command Syntax

```
debug rsvp hexdump
no debug rsvp hexdump
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp hexdump
```

debug rsvp nsm

Use this command to enable the NSM debugging option for an RSVP daemon.

Use the `no` parameter with this command to stop logging NSM debugging information.

Command Syntax

```
debug rsvp nsm
no debug rsvp nsm
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp nsm
```

debug rsvp packet

Use this command to enable packet debugging options for an RSVP daemon. Using the `in` option command enables debugging for incoming packets. Using the `out` option command enables debugging for outgoing packets.

Use the `no` parameter with these commands to stop logging debugging information.

Command Syntax

```
debug rsvp packet
debug rsvp packet in
debug rsvp packet out
no debug rsvp packet
no debug rsvp packet in
no debug rsvp packet out
```

Parameters

None

Command Mode

Privileged Exec and Configure modes

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#debug rsvp packet in
#debug rsvp packet out
```

description (rsvp-bypass)

Use this command to add a description to the rsvp-bypass or update an existing description.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
description LINE
no description
```

Parameters

`LINE`	Line describing the RSVP tunnel

Default

By default, rsvp bypass description is empty.

Command Mode

Rsvp-bypass mode

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#description this_is_the_description
(config-bypass)#no description
```

description (rsvp-path)

Use this command to add a description to the rsvp-path or update an existing description.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
description LINE
no description
```

Parameters

`LINE`	Line describing the RSVP path

Default

By default, rsvp path description is empty.

Command Mode

Rsvp-path mode

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#rsvp-path mypath
(config-path)#description this_is_the_description
(config-path)#no description
```

description (rsvp-trunk)

Use this command to add a description to the rsvp-trunk or update an existing description.

Use the `no` parameter with this command to disable the configuration.

Command Syntax

```
description LINE
no description
```

Parameters

`LINE`	Line describing the RSVP tunnel

Default

By default, rsvp trunk description is empty.

Command Mode

Rsvp-trunk mode.

Applicability

This command was introduced in OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#description this_is_the_description
(config-trunk)#no description
```

disable-rsvp

Use this command to disable RSVP message exchange on an interface.

RSVP can be enabled using the enable-rsvp command.

Command Syntax

```
disable-rsvp
```

Parameters

None

Default

By default, RSVP message exchange is disabled on an interface.

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#disable-rsvp
```

enable-rsvp

Use this command to enable RSVP message exchange on an interface.

Note: To use this command, the corresponding interface needs to be enabled for label-switching using the label-switching command.

See disable-rsvp to undo the effects of this command.

Command Syntax

```
enable-rsvp
```

Parameters

None

Default

By default, RSVP message exchange is disabled.

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth1
(config-if)#enable-rsvp
```

entropy-label-capability

Use this command to share the load across multiple members of a LAG port in the core of an MPLS network by using entropy labels.

Note: Use the `no` form of the command to disable the use of entropy labels

Command Syntax

```
entropy-label-capability
no entropy-label-capability
```

Parameters

None

Default

By default, entropy labels are not used.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 3.0.

Examples

```
#configure terminal
(config)router rsvp
(config-router)#entropy-label-capability
```

explicit-null

Use this command to send explicit-null labels to upstream router, instead of implicit-null labels.

If php is enabled then implicit-null label is advertised, then the penultimate hop removes the label and sends the packet as a plain IP packet to the egress router. The explicit-null command advertises label 0 and retains the label so the egress router can pop it. For details about usage of explicit-null, please refer to *RFC 3032*.

Use the `no` parameter with this command to stop sending explicit-null labels for directly-connected FECs to upstream router and resume sending non reserved labels.

Command Syntax

```
explicit-null
no explicit-null
```

Parameters

None

Default

By default, no php is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#explicit-null
```

ext-tunnel-id A.B.C.D

Use this command to configure an extended-tunnel identifier as an IPv4 address. These identifiers are used in RSVP messages. If no extended-tunnel ID is specified, the LSR-ID for the router is used as the extended-tunnel ID for all LSPs. The extended-tunnel ID is a simple way of identifying all LSPs belonging to the same trunk.

Use the `no` parameter with this command to remove a configured extended-tunnel ID.

Command Syntax

```
ext-tunnel-id A.B.C.D
no ext-tunnel-id
```

Parameters

`A.B.C.D`	Extended tunnel identifier for this trunk in IPv4 address format

Default

By default, the LSR-ID of the router is used as the extended-tunnel ID for all sessions.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#ext-tunnel-id 10.10.10.30

(config)#rsvp-trunk t1
(config-trunk)#no ext-tunnel-id
```

from A.B.C.D

Use this command to specify a “from” IPv4 address for the RSVP daemon. This command can be invoked from either the router rsvp mode or from the rsvp-trunk mode. In the RSVP router mode, this command defines the source address as an IPv4 packet sent out by the RSVP daemon. In the RSVP trunk mode, this command indicates a sender’s address in the sender template object that is used in path messages.

Use the `no` parameter with this command to revert to the default settings.

Command Syntax

```
from A.B.C.D
no from
```

Parameters

`A.B.C.D`	When in trunk mode, this is the IPv4 address of a tunnel ingress node
`A.B.C.D`	When in router mode, this is the loopback IPv4 address

Default

By default, from A.B.C.D is enabled

Command Mode

Router or Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#from 10.10.0.5

#configure terminal
(config)#router rsvp
(config-router)#from 10.10.0.5
```

graceful-restart

Use this command to enable RSVP-TE graceful restart capability on a router. This is a global parameter. RSVP-TE determines whether or not to send the graceful restart capability object in its hello message. However, this capability also depends on support for graceful restart on the neighbor router.

The following conditions must be met in order to activate RSVP-TE graceful restart:

- This command is used on the local router.
- The neighbor router is explicitly set with either the entropy-label-capability or neighbor X:X::X:X command.
- The neighbor router supports graceful restart, and it is activated.

Command Syntax

```
graceful-restart
no graceful-restart
```

Parameters

None

Default

Graceful restart is disabled by default.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#graceful-restart
(config-router)#no graceful-restart
```

graceful-restart recovery-time

Use this command to set a recovery time for an RSVP-TE graceful restart configuration.

Use the `no` parameter with this command to reset the recovery time.

Command Syntax

```
graceful-restart recovery-time <60000-3600000>
no graceful-restart recovery-time
```

Parameters

`<60000-3600000>`Recovery time value in milliseconds

Default

Default value is 360000 ms.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#graceful-restart recovery-time 600000
```

graceful-restart restart-time

Use this command to set a restart time for an RSVP-TE graceful restart configuration.

Use the `no` parameter with this command to reset the restart time.

Command Syntax

```
graceful-restart restart-time <10000-600000>
no graceful-restart restart-time
```

Parameters

`<10000-600000>`	Restart time value in milliseconds

Default

Default value is 180000 ms.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 5.0.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#graceful-restart restart-time 100000
```

hello-interval

Use this command to set an interval between Hello packets.

Used as a global command, this value is over-ridden by the hello-interval set on the interface (see rsvp hello-interval). For optimum performance, set this value no more than one-third of the hello-timeout value.

Use the `no` parameter with this command to return to the default hello interval value.

Command Syntax

```
hello-interval <1-65535>
no hello-interval
```

Parameter

`<1-65535>`	The time in seconds after which hello packets are sent

Default

By default, hello interval is 2 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#hello-interval 5

(config)#router rsvp
(config-router)#no hello-interval
```

hello-receipt

Use this command to enable the receipt of Hello messages from peers.

Use the `no` parameter with this command to disable the exchange of Hello messages.

Command Syntax

```
hello-receipt
no hello-receipt
```

Parameters

None

Default

By default, hello receipt is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#hello-receipt
```

hello-timeout

Use this command to set the RSVP hello timeout. If an LSR has not received a hello message from a peer within the number of seconds set with this command, all sessions shared with this peer are reset. The hello-timeout determines how long an RSVP node waits for a hello message before declaring a neighbor to be down.

Use the `no` parameter with this command to set the default hello timeout value.

Command Syntax

```
hello-timeout <1-65535>
```

```
no hello-timeout
```

Parameter

`<1-65535>`	Time in seconds to receive a hello message.

Default

By default, hello-timeout value is 7 seconds.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#hello-timeout 12

(config)#router rsvp
(config-router)#no hello-timeout
```

keep-multiplier

Use this command to configure the constant to be used to calculate a valid reservation lifetime for a Labeled Switched Path (LSP).

The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid reservation lifetime for an LSP. Use the following formula to calculate the reservation lifetime for an LSP:

```
L >= (K + 0.5)* 1.5 * R
```

`K` = keep-multiplier

`R` = refresh timer

The router sends refresh messages periodically so that the neighbors do not timeout.

Use the `no` parameter with this command to return to the default keep-multiplier setting.

Command Syntax

```
keep-multiplier <1-255>
no keep-multiplier <1-255>
```

Parameters

`<1-255>`	The keep-multiplier value

Default

By default, keep-multiplier value is 3

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#keep-multiplier 2
```

loop-detection

Use this command to turn on loop detection for Path and Reservation messages exchanged between LSRs.

Use the no loop-detection command to return to default settings.

Command Syntax

```
loop-detection
```

Parameters

None

Default

By default, loop detection is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#loop-detection
```

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lsp-metric

Use this command to set LSP absolute metric or relative metric for IGP Shortcut use

Use the `no` parameter along with this command to unset the LSP metirc for IGP shortcut.

Command Syntax

```
lsp-metric absolute <1-65535>
lsp-metric relative (<-65535-0>|<1-65535>)
no lsp-metric absolute (<1-65535>|)
no lsp-metric relative (<-65535-0>|<1-65535>|)
```

Parameters

absolute	Absolute metric
relative	Relative metric
<1-65535>	Metric value
<-65535-0>	The keep-multiplier value

Command Mode

RSVP Trunk mode

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#exit
(config)#rsvp-trunk T1
(config-trunk)#lsp-metric absolute 10
(config-trunk)#lsp-metric relative 10
```

lsp-reoptimization-timer

Use this command to set the re-optimization interval timer.

Use the no parameter with this command to set the default re-optimization interval (5 minutes).

Command Syntax

```
lsp-reoptimization-timer <1-240>
```

Parameter

`<1-240>`	The interval in minutes after which LSP re-optimization will take place.

Default

By default, the re-optimization timer interval is 5 minutes.

Command Mode

RSVP router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
(config)#router rsvp
(config-router)#lsp-reoptimization-timer 10
(config)#router rsvp
(config-router)#no lsp-reoptimization-timer
```

map-route A.B.C.D

Use this command to map a route using an IPv4 to an RSVP trunk. If the primary LSP for a trunk goes down, all mapped routes are sent automatically to a secondary LSP configured as backup for a primary LSP.

Use the `no` parameter with this command to unmap routes from specified trunks.

Command Syntax

```
map-route A.B.C.D/M
map-route A.B.C.D/M CLASS
map-route A.B.C.D A.B.C.D
map-route A.B.C.D A.B.C.D CLASS
no map-route A.B.C.D/M
no map-route A.B.C.D/M CLASS
no map-route A.B.C.D A.B.C.D
no map-route A.B.C.D A.B.C.D CLASS
```

Parameters

`A.B.C.D/M`	Prefix to map, plus mask
`A.B.C.D`	Prefix to be mapped
`A.B.C.D`	Prefix mask
`CLASS`	Incoming DiffServ Class (for example, be, ef, etc.) to map to the RSVP trunk

Default

By default, map route A.B.C.D/M is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 2.2.2.2/16
```

neighbor A.B.C.D

Use this command to designate a neighbor IPv4 address to use when exchanging hello messages. Any neighbor hello message that is not explicitly identified is rejected.

Use the `no` parameter with this command to remove an IP neighbor from the system.

Command Syntax

```
neighbor A.B.C.D
no neighbor A.B.C.D
```

Parameters

None

Default

By default, neighbor A.B.C.D is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#neighbor 10.10.0.5
```

neighbor X:X::X:X

Use this command to designate a neighbor IPv6 address to use when exchanging hello messages. Any neighbor hello message that is not explicitly identified is rejected.

Use the `no` parameter with this command to remove an IP neighbor from the system.

Command Syntax

```
neighbor X:X::X:X

no neighbor X:X::X:X
```

Parameters

None

Default

By default, neighbor X:X::X:X is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#neighbor 3ffe::3:34
```

no cspf

Use this command to disable the use of the Constrained Shortest Path First (CSPF) server for all RSVP sessions. Disable CSPF when no nodes support the required traffic engineering extensions.

When this command is executed in Router mode, CSPF is disabled for all configured RSVP sessions, and all RSVP sessions configured from this point forward. If the default CSPF per RSVP session is enabled, it will be disabled. The CSPF status for RSVP sessions can be verified using the show rsvp session command with the detail option.

Use the cspf command to revert to the default settings.

Note: When CSPF is disabled, path is not calculated taking constraints into consideration. Path message is sent to the next hop based on IGP best route. In this case, ERO is not included in path message and all constraints are included.

Command Syntax

```
no cspf
```

Parameters

None

Default

By default, no cspf is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Router mode to disable CSPF for all RSVP sessions.

```
#configure terminal
(config)#router rsvp
(config-router)#no cspf
```

no igp-shortcut

Use this command to disable Interior Gateway Protocol (IGP) shortcut.

Command Syntax

```
no igp-shortcut
```

Parameters

None

Command Mode

Trunk mode

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no igp-shortcut
```

no loop-detection

Use this command to turn off loop detection for Path and Reservation messages exchanged between LSRs. When a Path or Resv message is received, the primary IP address of the incoming interface is compared with the received route record list.

Use the loop-detection command to revert to default settings.

Command Syntax

```
no loop-detection
```

Parameters

None

Default

By default, no loop detection is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#no loop-detection
```

no php

Use this command to disable Penultimate-Hop-Popping (PHP) for the router. An egress router sends neither implicit null label nor explicit null for LSPs. When `no php` command is used, the egress router sends non-reserved labels (those labels in the label pool range allotted to RSVP) to the upstream router and retains the labels till the egress router.

Note: Use the show rsvp command to display the status of Penultimate-Hop-Popping.

Command Syntax

```
no php
```

Parameters

None

Default

By default, no php is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#no php
```

no record

Use this command to disable recording of the route taken by Path and Reservation Request (Resv) messages that confirm establishment of reservations and are used to identify errors. The routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Command Syntax

```
no record
```

Parameters

None

Default

Routes are recorded by default.

Command Mode

RSVP Bypass mode

Examples

```
#configure terminal
(config)#rsvp-bypass bypassname
(config-bypass)#no record
```

no refresh-path-parsing

Use this command to disable parsing of Refresh PATH messages received from upstream nodes. Enable this command to minimize message processing by RSVP, if you are sure that a particular router does not need to parse Refresh-PATH messages to check for changes because LSPs passing through this router are not required to be updated, simultaneously.

Use the refresh-path-parsing command to revert to the default settings.

Command Syntax

```
no refresh-path-parsing
```

Parameters

None

Default

By default, refresh-path-parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#no refresh-path-parsing
```

no refresh-resv-parsing

Use this command to disable parsing of Refresh RESV messages received from upstream nodes. Enable this command to minimize message processing by RSVP, if you are sure that a particular router does not need to parse Refresh RESV messages to check for changes because LSPs passing through this router are not required to be updated simultaneously.

Command Syntax

```
no refresh-resv-parsing
```

Parameters

None

Default

By default, refresh reservation parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#no refresh-resv-parsing
```

path-option dynamic pce

Use this command to indicate that a tunnel must query PCE for path computation.

Command Syntax

```
path-option dynamic pce
```

Parameters

None

Command Mode

RSVP trunk mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk ipv4
(config-trunk)#path-option dynamic pce
(config-trunk)#pce entity 1
```

php

Use this command to enable Penultimate-Hop-Popping for the router. An egress router send an implicit-null label (3) to the upstream router.

Note: Use the show rsvp command to display the status of Penultimate-Hop-Popping.

Use the no php command to revert to the default setting.

Note: On Qumran1 (QAX, QMX, and QUX) platforms, when a primary session has non-implicit-null out label and a backup session has implicit-null out label, then L3 services do not work when the session is at backup state. i.e., mpls ping, L3 ping, and map route traffic will fail as label popped packets cannot select the next header ethertype properly.

Command Syntax

```
php
```

Parameters

None

Default

By default, no php is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#php
```

primary ADMIN-GROUP-NAME

Use this command to configure primary administrative groups. Administrative groups are manually assigned attributes that describe the color of links, so that links with the same color are in one class. These groups are used to implement different policy-based LSP setups. Administrative group attributes can be included or excluded for an LSP or for a path's primary and secondary paths.

Note: A link can be added to a specific Administrative Group via the Network Services Module. Refer to the *Network Services Module Command Reference* for details.

Use the `no` parameter to remove a previously configured group from an administrative group list.

Command Syntax

```
primary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
primary (include-any|exclude-any) ADMIN-GROUP-NAME
primary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
primary (include-any|exclude-any) ADMIN-GROUP-NAME
```

Parameters

`include-any`	Include any attributes
`include-all`	Include all attributes
`exclude-any`	Exclude any attribute
`ADMIN-GROUP-NAME`	Administrative group name

Default

By default, primary admin group name is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary exclude-any myadmingroup

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary include-all admingrp2

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary include-any admingrp2
```

primary affinity

Use this command to enable sending of session attribute objects with resource affinity data.

Use the no primary affinity command to disable sending of session attribute objects.

Command Syntax

```
primary affinity
```

Parameters

None

Default

By default, primary affinity is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary affinity
```

primary bandwidth

Use this command to reserve the primary bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is specified in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although exchanges labels.

Use the `no` parameter to remove configured bandwidth information.

Command Syntax

```
primary bandwidth BANDWIDTH
no primary bandwidth BANDWIDTH
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

The default bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary bandwidth 100m
```

primary cspf

Use this command to enable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions. When CSPF is turned off globally, it cannot be enabled for any LSP.

The CSPF server computes paths for LSPs that are subject to constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP, but also the links. It attempts to minimize congestion by intelligently balancing the network load.

Use the no primary affinity command to revert to the default settings.

Note: CSPF server information is not signaled across session and hence sessions in transit and egress nodes will not be aware of the CSPF server. So, in multi CSPF scenarios, neighbor down event from a CSPF server restart all sessions irrespective of which CSPF server sessions were using.

Command Syntax

```
primary cspf
```

Parameters

None

Default

By default, primary cspf is enabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary cspf
```

primary cspf-retry-limit

Use this command to specify the number of retries that CSPF should carry out for a request received from RSVP.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
primary cspf-retry-limit <1-65535>
no primary cspf-retry-limit
```

Parameter

`<1-65535>`	Set the number of times CSPF should retry for this LSP

Default

By default, retry-limit is 0.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary cspf-retry-limit 535

(config)#rsvp-trunk T1
(config-trunk)#no primary cspf-retry-limit
```

primary cspf-retry-timer

Use this command to specify the time between each retry that CSPF might carry out for a request received from RSVP.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
primary cspf-retry-timer <1-600>
no primary cspf-retry-timer
```

Parameter

`<1-600>`	Timeout between successive retries, in seconds

Default

By default, retry-timer is 0

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary cspf-retry-timer 45

(config)#rsvp-trunk T1
(config-trunk)#no primary cspf-retry-timer
```

primary filter

Use this command to set the filter to the fixed or shared style for an LSP.

- The shared filter style identifies a shared reservation environment. It creates a single reservation into which flows from all senders are mixed.
- The fixed filter style designates a distinct reservation. A distinct reservation request is created for data packets from a particular sender. The fixed filter style is also used style to prevent rerouting of an LSP and to prevent another LSP from using this bandwidth.

Use the `no` parameter to reset the configured filter to the default.

Command Syntax

```
primary filter fixed
no primary filter
```

Parameters

`fixed`	Use a fixed filter for this LSP

Default

By default, primary filter is shared-explicit.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary filter fixed
```

primary hold-priority

Use this command to configure the hold priority value for the selected trunk. In case of insufficient bandwidth, remove less important existing LSPs to free up a portion of the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the `no` parameter to reset the trunk to the default hold-priority value.

Command Syntax

```
primary hold-priority <0-7>
no primary hold-priority
```

Parameter

`<0-7>`	Set a hold priority for the LSP

Default

The default hold-priority value is 0, which is the highest. Once a session is configured with a hold priority of 0, no other session can preempt it.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary hold-priority 2
```

primary hop-limit

Use this command to specify a limit of hops for an RSVP trunk. Hop-limit data is sent to the CSPF server if CSPF is used.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the primary path, if a primary path has been configured. If the number of hops in the primary path exceeds the hop-limit configured, no `Path` messages are sent, and any existing session is torn down. If no primary path is configured, the trunk is processed normally and Path messages are sent.

Use the `no` parameter to reset the trunk to the default hop-limit value.

Command Syntax

```
primary hop-limit <1-255>
no primary hop-limit <1-255>
no primary hop-limit
```

Parameters

`<1-255>`	Set the number of acceptable hops for the LSP

Default

By default, primary hop limit is 255

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary hop-limit 23
```

primary label-record

Use this command to record all labels exchanged between RSVP-enabled routers during the reservation setup process.

Use the `no` parameter with this command to turn off recording.

Command Syntax

```
primary label-record
no primary label-record
```

Parameters

None

Default

By default, primary label record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary label-record
```

primary local-protection

Use this command to enable the local repair of explicit routes for which this router is a transit node.

Use the `no` parameter with this command to disable local repair of explicit routes.

Command Syntax

```
primary local-protection
no primary local-protection
```

Parameters

None

Default

By default, primary local protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary local-protection
```

no primary affinity

Use this command to disable the use of sending out session attribute objects with resource affinity data.

Use the primary affinity command to return to the default settings.

Command Syntax

```
no primary affinity
```

Parameters

None

Default

By default, primary no affinity is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no primary affinity
```

no primary cspf

Use this command to disable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions. When CSPF is turned off globally it cannot be enabled for any LSP. If used per LSP, it can be used to turn off CSPF computation for a specific LSP.

Disable CSPF when all nodes do not support the required traffic engineering extensions, and configure LSPs manually to use an explicit path. The LSP is then established only along the path specified by the operator.

Use the primary cspf command to enable this setting.

Command Syntax

```
no primary cspf
```

Parameters

None

Default

By default, no primary cspf is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Trunk mode to disable CSPF for the primary LSP.

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no primary cspf
```

no primary record

Use this command to disable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Use the primary record command to return to the default settings.

Command Syntax

```
no primary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no primary record
```

primary path

Use this command to specify an RSVP path to be used. The `PATHNAME` in this command is the string (name) used to identify an RSVP path defined for the node (refer to `rsvp-path` command).

Use the `no` parameter with this command to remove a configured RSVP path.

Command Syntax

```
primary path PATHNAME
no primary path
```

Parameters

PATHNAME	The name of the path to use

Default

By default, primary path is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary path mypath
```

primary record

Use this command to enable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means or the Route Record Object (RRO) in RSVP messages.

Use the no primary record command to disable recording of routes.

Command Syntax

```
primary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary record
```

primary retry-limit

Use this command to specify a retry count this RSVP Trunk.

If a session is in a `nonexistent` state due to a path error message, the system tries to recreate the LSP for the number of times specified by the `retry-limit` command.

Although the same retry command controls both the trunk and the session, the retry-limit value affects only the session and not the trunk. If the trunk is in an `incomplete` state, the code keeps trying forever to bring it to a `complete` state regardless of the retry-limit value.

Use the `no` parameter with this command to revert to the default retry-limit value.

Command Syntax

```
primary retry-limit <1-65535>
no primary retry-limit
```

Parameter

<1-65535>	The set number of times the system should try setting up the LSP

Default

By default, the retry-limit value is 0, and the trunk and session try to create the LSP indefinitely.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary retry-limit 256
```

primary retry-timer

Use this command to specify a retry interval for an RSVP Trunk. When an ingress node tries to configure an LSP and the setup fails due to the receipt of a Path Error message, the system waits for the time configured with this command, before retrying the LSP setup process.

Use the `no` parameter with this command to revert to the default retry-time value.

Command Syntax

```
primary retry-timer <1-600>
no primary retry-timer
```

Parameter

`<1-600>`	Time in seconds after which the system should retry setting up the LSP

Default

By default, retry-timer value is 30 seconds.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary retry-timer 12
```

primary reuse-route-record

Use this command to use the updated Route Record List as an Explicit Route (with all strict nodes) when a path message is sent out at the next refresh.

The ERO list contains the hops to be taken to reach the egress from the current LSR. If CSPF is not available, to place an ERO with all strict routes, use this command to modify the ERO after receiving the Resv message. The future Path messages have the ERO with all strict nodes, identifying each and every node to be traversed.

Use the `no` parameter with this command to disable the use of the Route Record List as the explicit route.

Command Syntax

```
primary reuse-route-record
no primary reuse-route-record
```

Parameters

None

Default

By default, primary reuse route record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary reuse-route-record
```

primary setup-priority

Use this command to configure a setup priority value for a trunk. In case of insufficient bandwidth, users must remove less important LSPs to free up the bandwidth. This can be done by preempting one or more of the existing LSPs. The primary setup priority determines if a new LSP can preempt an existing LSP.

The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the `no` parameter with this command to revert to the default primary setup priority value.

Command Syntax

```
primary setup-priority <0-7>
no primary setup-priority
```

Parameters

`<0-7>`	Set the priority value

Default

By default, setup priority is 7, which is the lowest.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary setup-priority 2
```

primary traffic

Use this command to specify the traffic type for this RSVP Trunk.

Use the `no` parameter with this command to reset the configured traffic type.

Command Syntax

```
primary traffic (guaranteed|controlled-load)
no primary traffic
```

Parameters

`controlled-load`	Controlled loaded traffic
`guaranteed`	Guaranteed traffic

Default

By default, primary traffic type is controlled-load

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#primary traffic guaranteed
```

refresh-time

Use this command to configure RSVP refresh interval timer. The timer specifies the interval after which Path and/ or Reservation Request (Resv) messages will be sent out.

The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid Reservation Lifetime for an LSP. Refresh time regulates the interval between Refresh messages which include Path and Reservation Request (Resv) messages. Refresh messages are sent periodically so that reservation does not timeout in the neighboring nodes. Each sender and receiver host sends Path and Resv messages, downstream and upstream respectively, along the paths.

Use the `no` parameter with this command to return to the default refresh-time interval.

Command Syntax

```
refresh-time <1-65535>
no refresh-time <1-65535>
no refresh-time
```

Parameter

`<1-65535>`	The duration for which messages are sent, in seconds

Default

By default, refresh-time interval is 30 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#refresh-time 20
```

refresh-path-parsing

Use this command to disable parsing of Refresh PATH messages received from upstream nodes. Use this command to minimize message processing by RSVP when you are sure that a particular router does not need to parse Refresh-PATH messages to check for changes, because LSPs passing through this router are not required to be updated simultaneously.

Use the no refresh-path-parsing command to disable this setting.

Command Syntax

```
refresh-path-parsing
```

Parameters

None

Default

By default, refresh-path-parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#refresh-path-parsing
```

refresh-resv-parsing

Use this command to disable parsing of Refresh RESV messages received from upstream nodes. Use this command to minimize message processing by RSVP when you are sure that a particular router does not need to parse Refresh RESV messages to check for changes because LSPs passing through this router are not required to be updated simultaneously.

Use the no refresh-resv-parsing command to disable this setting.

Command Syntax

```
refresh-resv-parsing
```

Parameters

None

Default

By default, refresh reservation parsing is enabled.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
Router#configure terminal
Router(config)#router rsvp
Router(config-router)#refresh-resv-parsing
```

reoptimize

Use this command to enable re-optimization of the RSVP primary LSP with the rsvp-trunk force-reoptimize command.

Use the no parameter with this command to disable re-optimization of the RSVP primary LSP.

Command Syntax

```
reoptimize
```

Parameters

None

Command Mode

Trunk mode

Applicability

This command was introduced in OcNOS version 1.3.4.

Examples

```
(config)#rsvp-trunk t1
(config-trunk)#reoptimize
(config)#rsvp-trunk t1
(config-trunk)#no reoptimize
```

restart rsvp graceful

Use this command to restart RSVP gracefully.

To restart RSVP gracefully, you must give the graceful-restart command to enable graceful restart capability on the device in RSVP router mode.

Command Syntax

```
restart rsvp graceful
```

Parameter

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#restart rsvp graceful
    #restart rsvp graceful
    % Warning : RSVP process will stop and needs to restart manually,
    You may loose ospf configuration, if not saved
    Proceed for graceful restart? (y/n):y
```

revert-timer

Use this command to specify a "revert-timer" for the RSVP daemon. This command can be invoked from either the router rsvp mode or from the rsvp-trunk mode. In the RSVP router mode, this command defines the revert timer from secondary session to primary session for the RSVP daemon.

Use the `no` parameter with this command to revert to the default settings.

Command Syntax

```
revert-timer <1-65535>
no revert-timer (<1-65535>|)
```

Parameters

`<1-65535>`	Hold-on timer before revert back to primary session

Default

By default, `no rever-timer` is configured

Command Mode

Router or Trunk mode

Applicability

This command was introduced in OcNOS version 4.2.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#revert-timer 30

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no revert-timer

#configure terminal
(config)#router rsvp
(config-router)#revert-timer 40
#configure terminal
(config)#router rsvp
(config-router)#no revert-timer
```

router rsvp

Use this command to enter router mode from configure mode and to enable the RSVP daemon, if it is not already enabled.

Use the `no` parameter with this command to disable RSVP on the node.

Command Syntax

```
router rsvp
no router rsvp
```

Parameters

None

Default

RSVP is started only if this command is executed.

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

The command prompt changes from config to config-router, as illustrated below:

```
#configure terminal
(config)#router rsvp
(config-router)#

(config-router)#exit
(config)#no router rsvp
```

rsvp hello-interval

Use this command to enable the sending of Hello packets on the interface and to set the interval value between successive Hello packets to neighbor. For optimum performance, set this value to less than one-third the value of the configured RSVP hello-timeout. See the rsvp hello-timeout command for more information.

Note: This is an interface-specific command and when not used, the global hello-interval state applies.

Use the `no` parameter with this command to return to the default hello interval value.

Command Syntax

```
rsvp hello-interval <1-65535>
no rsvp hello-interval
```

Parameter

`<1-65535>`	RSVP hello interval in seconds

Default

By default, RSVP hello interval is 2 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp hello-interval 110

(config)#interface eth0
(config-if)#no rsvp hello-interval
```

rsvp hello-receipt

Use this command to enable the receipt of hello messages from peers connected through this interface. This is an interface-specific command and when not used, the global hello-receipt command applies.

Use the `no` parameter with this command to disable the exchange of hello messages for this interface.

Command Syntax

```
rsvp hello-receipt
no rsvp hello-receipt
```

Parameters

None

Default

By default, rsvp hello receipt is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp hello-receipt
```

rsvp hello-timeout

This command determines how long an RSVP node should wait for a hello message before declaring a neighbor to be down. If an LSR does not received a hello message from a peer connected to an interface within the specified duration, the LSR resets all sessions that are shared with this particular peer. This is an interface-specific command and when not used, the global hello-timeout command applies.

Use the `no` parameter to revert to the default hello timeout value.

Command Syntax

```
rsvp hello-timeout <1-65535>
no rsvp hello-timeout
```

Parameters

`<1-65535>`	Time to receive a hello message, in seconds

Default

By default, hello-timeout value is 7 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp hello-timeout 550

(config)#interface eth0
(config-if)#no rsvp hello-timeout
```

rsvp keep-multiplier

This command sets the constant for calculating a valid reservation lifetime for an LSP, which allows messages to be exchanged through this interface. This is an interface-specific command and when not specified, the global keep-multiplier command applies.

Reservation lifetime is the duration of bandwidth reservation for the LSP. The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid reservation lifetime for an LSP. Use the following formula to calculate the reservation lifetime for an LSP:

```
L >= (K + 0.5)* 1.5 * R
```

`K` = keep-multiplier

`R` = refresh timer

Refresh messages are sent periodically so that neighbors do not timeout.

Use the `no` parameter with this command to return to the global keep-multiplier value.

Command Syntax

```
rsvp keep-multiplier <1-255>
no rsvp keep-multiplier <1-255>
```

Parameter

`<1-255>`	Set a value for the lifetime constant

Default

By default RSVP keep-multiplier value is 3

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp keep-multiplier 3

(config)#interface eth0
(config-if)#no rsvp keep-multiplier
```

rsvp refresh-time

Use this command to configure RSVP refresh interval timer for the current interface. This is an interface-specific command and when not used, the global refresh-time command applies.

The refresh time and keep multiplier are two interrelated timing parameters used to calculate the valid reservation lifetime for an LSP. Refresh time regulates the interval between refresh messages that include path and reservation request (Resv) messages. Refresh messages are sent periodically so that the reservation does not timeout in the neighboring nodes. Each sender and receiver host sends path and resv messages, downstream and upstream respectively, along the paths.

Use the `no` parameter with this command to revert to the refresh-time value set in RSVP mode.

Command Syntax

```
rsvp refresh-time <1-65535>
no rsvp refresh-time <1-65535>
```

Parameter

`<1-65535>`	The duration for which messages are sent, in seconds

Default

By default, refresh interval is 30 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp refresh-time 5055

(config)#interface eth0
(config-if)#no rsvp refresh-time
```

rsvp-path

Use this command to create a new RSVP path or to enter the `Path` command mode. In this mode, you can add or delete paths and also specify the path to be loose or strict.

Use the `no` parameter with this command to delete the path and its specified hops.

Command Syntax

```
rsvp-path PATHNAME
no rsvp-path PATHNAME
```

Parameter

PATHNAME	Name of the path

Default

By default, rsvp path is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-path mypath
(config-path)#
```

rsvp-trunk

Use this command to create a new RSVP trunk. When the trunk is created, the attributes required to configure an explicitly-routed or traditionally-routed LSP are set. Once a trunk is configured with the required attributes, an RSVP session (and PSB) is created for this trunk, which enables the exchange of messages and completes the LSP setup.

This command also modifies an existing RSVP path to configure an explicitly-routed or traditionally-routed LSP. In addition, this command can be used to set the address family (IPv4) of an RSVP trunk. If no address family is assigned, the default value is used. If the address family is already set, a check is made to see whether the address family configured and the one already in the database are the same. An error message is returned if the two do not match.

Use the `no` parameter with this command to remove an RSVP trunk and all configured attributes, except the primary path.

Note: The RSVP trunk's name (`TRUNKNAME`) is limited to 32 characters.

Command Syntax

```
rsvp-trunk TRUNKNAME ipv4
no rsvp-trunk TRUNKNAME
```

Parameters

`TRUNKNAME`	Name to use for the trunk
`ipv4`	IPv4 address family trunk

Default

By default, rsvp trunk is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

The command prompt changes from `config` to `config-trunk` as illustrated below:

```
#configure terminal
(config)#rsvp-trunk mytrunk ipv4
(config-trunk)#
```

rsvp-trunk force-reoptimize

Use this command to force re-optimize a particular primary LSP. Re-optimization of the LSP must have been enabled with the reoptimize command.

Command Syntax

```
rsvp-trunk TRUNKNAME force-reoptimize
```

Parameters

TRUNKNAME	Name of the trunk

Default

NA.

Command Mode

Execute mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#rsvp-trunk t1 force-reoptimize
```

rsvp-trunk force-switchover-secondary

Use this command to force switchover a secondary LSP. This command is recommended for limited use on a stable system when there is a need for software upgrade without traffic impact.

Note: This command is supported on secondary configured tunnels and not on multiple secondary configured tunnels.

Command Syntax

```
rsvp-trunk TRUNKNAME force-switchover-secondary (off|on)
```

Parameters

`TRUNKNAME` Name of the trunk

`force-switchover-secondary` (off|on)

Force switchover to secondary

Default

NA.

Command Mode

Execute mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#rsvp-trunk <Trunk-Name> force-switchover-secondary off
```

rsvp-trunk-restart

Use this command to restart the RSVP trunk. This command “kills” an existing LSP and restarts the LSP setup process.

Command Syntax

```
rsvp-trunk-restart
```

Parameters

None

Default

By default, rsvp trunk restart is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#rsvp-trunk-restart
```

secondary ADMIN-GROUP-NAME

Use this command to configure secondary administrative groups. Administrative groups are manually assigned attributes that describe the color of links, so that links with the same color are in one class. These groups are used to implement different policy-based LSP setups. Administrative group attributes can be included or excluded for an LSP or for a path's primary and secondary paths.

Note: A link can be added to a specific Administrative Group via NSM. Refer to the *Network Services Module Command Reference* for details.

Use the `no` parameter to remove a previously set group from an administrative group list.

Command Syntax

```
secondary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
secondary (include-any|exclude-any) ADMIN-GROUP-NAME
no secondary (include-any|include-all|exclude-any) ADMIN-GROUP-NAME
no secondary (include-any|exclude-any) ADMIN-GROUP-NAME
```

Parameters

`include-any`	Include any attribute
`include-all`	Include all attribute
`exclude-any`	Exclude any attribute
`ADMIN-GROUP-NAME`	Administrative group name

Default

By default, secondary admin group name is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary exclude-any myadmingroup

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary include-any myadmingroup

#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary include-all myadmingroup
```

secondary bandwidth

Use this command to reserve the bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is set in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although label exchanges are possible.

Use the `no` parameter with this command to unset the configured bandwidth information.

Command Syntax

```
secondary bandwidth BANDWIDTH
no secondary bandwidth BANDWIDTH
no secondary bandwidth
```

Parameter

`BANDWIDTH`	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

By default, bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary bandwidth 100m
```

secondary cspf

Use this command to enable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions.

The CSPF server computes paths for LSPs that are subject to constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP, but also the links. It attempts to minimize congestion by intelligently balancing the network load.

Use the no secondary cspf command to revert to the default settings.

Note: CSPF server information is not signaled across session and hence sessions in transit and egress nodes will not be aware of the CSPF server. So, in multi CSPF scenarios, neighbor down event from a CSPF server restart all sessions irrespective of which CSPF server sessions were using.

Command Syntax

```
secondary cspf
```

Parameters

None

Default

By default, secondary cspf is enabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Trunk mode to disable CSPF for the primary LSP.

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary cspf
```

secondary cspf-retry-limit

Use this command to specify the number of retries that CSPF should carry out for a request received from RSVP.

Use the `no` parameter with this command to remove this configuration.

Command Syntax

```
secondary cspf-retry-limit <1-65535>
no secondary cspf-retry-limit
```

Parameter

`<1-65535>`	The number of times CSPF should retry for this LSP

Default

By default, no retry limit for CSPF route calculations is configured, so the value is 0.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary cspf-retry-limit 535
```

secondary cspf-retry-timer

Use this command to specify the time between each retry that CSPF might carry out for a request received from RSVP.

Use the `no` parameter with this command to remove this configuration.

Command Syntax

```
secondary cspf-retry-timer <1-600>
no secondary cspf-retry-timer
```

Parameters

`<1-600>`	Timeout between successive retries, in seconds

Default

By default, no retry-timer configuration is defined for CSPF calculations, so the value is set to 0.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary cspf-retry-timer 45
```

secondary filter

Use this command to set the filter to fixed or shared filter style for RSVP trunk.

- The shared filter style identifies a shared reservation environment. It creates a single reservation into which flows from all senders are mixed.
- The fixed filter style designates a distinct reservation. A distinct reservation request is created for data packets from a particular sender. The fixed filter style is also used style to prevent rerouting of an LSP and to prevent another LSP from using this bandwidth.

Use the `no` parameter to reset the configured filter to the default style.

Command Syntax

```
secondary filter fixed
no secondary filter
```

Parameters

`fixed`	Use a Fixed Filter for this RSVP Trunk.

Default

By default, secondary filter is shared-explicit.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Usage

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary filter fixed
```

secondary hold-priority

Use this command to configure the hold priority value for the selected trunk.

In case of insufficient bandwidth, the user must remove any less important existing LSP to free up the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the `no` parameter to revert to the default hold-priority value.

Command Syntax

```
secondary hold-priority <0-7>
```

```
no secondary hold-priority
```

Parameter

`<0-7>`	Specify a value for hold priority

Default

The default hold-priority is 0, the highest value. Once a session is configured with a 0 hold priority value, no other session can preempt it.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary hold-priority 2
```

secondary hop-limit

Use this command to specify a limit of hops for an RSVP trunk.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the primary path, if a primary path has been configured. If the number of hops in the primary path exceed the hop-limit configured, no path messages are sent out and any existing session is torn down. If no primary path is configured, the trunk is processed normally and the path messages are sent out. The hop-limit data is sent to the CSPF server, if CSPF is being used.

Use the `no` parameter to revert to the default hop-limit value.

Command Syntax

```
secondary hop-limit <1-255>
no secondary hop-limit <1-255>
no secondary hop-limit
```

Parameter

`<1-255>`	The number of acceptable hops

Default

By default, secondary hop limit is 255

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary hop-limit 23
```

secondary label-record

Use this command to record all labels exchanged between RSVP enabled routers during the reservation setup process. This command records all labels exchanged for an LSP from the ingress to the egress, and helps with debugging.

Use the `no` parameter to turn off recording.

Command Syntax

```
secondary label-record

no secondary label-record
```

Default

By default, secondary label record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary label-record
```

secondary local-protection

Use this command to enable the local repair of explicit routes for which this router is a transit node.

Use the no parameter with this command to disable local repair of explicit routes.

Command Syntax

```
secondary local-protection
no secondary local-protection
```

Parameters

None

Default

By default, secondary local protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary local-protection
```

no secondary affinity

Use this command to disable the use of sending out session attribute objects with resource affinity data.

Use the secondary bandwidth command to revert to the default settings.

Command Syntax

```
no secondary affinity
```

Parameters

None

Default

By default, no secondary affinity is disabled.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no secondary affinity
```

no secondary cspf

Use this command to disable the use of Constrained Shortest Path First (CSPF) server for an explicit route to the egress, or all RSVP sessions.

If CSPF is turned off globally, it cannot be enabled for any LSP. If used per LSP, it can be used to turn off CSPF computation for a specific LSP. The CSPF server computes paths for LSPs that are subject to various constraints such as bandwidth, hop count, administrative groups, priority, and explicit routes. When computing paths for LSPs, CSPF considers not only the topology of the network and the attributes defined for the LSP, but, also the links. It attempts to minimize congestion by intelligently balancing the network load.

Disable CSPF when all nodes do not support the required traffic engineering extensions and configure LSPs manually to use an explicit path. The LSP is then established only along the path specified by the operator.

Use the secondary cspf command to revert to the default settings.

Command Syntax

```
no secondary cspf
```

Parameters

None

Default

By default, secondary no cspf is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

This example shows using the `no cspf` command in Trunk mode to disable CSPF for the primary LSP.

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no secondary cspf
```

no secondary record

This command is used to disable recording of the route taken by path and resv messages and confirms the establishment of reservations and to identify errors. Routes are recorded by means of the route record object (RRO) in an RSVP message.

Use the secondary record command to revert to the default settings.

Command Syntax

```
no secondary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#no secondary record
```

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secondary path

Use this command to specify an RSVP path to be used.

Use the `no` parameter with this command to remove a configured RSVP path.

Command Syntax

```
secondary path PATHNAME
no secondary path
```

Parameters

PATHNAME	The name of the path to be used. PATHNAME is a string (name) used to identify an RSVP path defined for the node (refer to the rsvp-path command).

Default

By default, secondary path is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary path mypath
```

secondary-priority path

Use this command to specify a RSVP path to be used for a specific priority secondary.

Use the no parameter with this command to remove a configured secondary-priority.

Command Syntax

```
secondary-priority <1-5> path PATHNAME
no secondary-priority <1-5>
```

Parameters

`<1-5>`	Secondary Priority value.
`PATHNAME`	The name of the path to be used. `PATHNAME` is a string (name) used to identify an RSVP path defined for the node (refer to the rsvp-path command).

Default

Secondary-priority can only be configured along with a path. Other attributes can only be associated post this command.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#secondary-priority 1 path sp1
(config)# rsvp-trunk t1
(config-trunk)#no secondary-priority 1
```

secondary-priority hold-priority

Use this command to configure the hold priority value for the secondary-priority lsp.

In case of insufficient bandwidth, the user must remove any less important existing LSP to free up the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the no parameter to revert to the default hold-priority value.

Command Syntax

```
secondary-priority <1-5> hold-priority <0-7>
no secondary-priority <1-5> hold-priority <0-7>
no secondary-priority <1-5> hold-priority
```

Parameters

<1-5>	Secondary Priority value.
<0-7>	Specify a value for hold priority.

Default

The default hold-priority is 0, the highest value. Once a session is configured with a 0 hold priority value, no other session can preempt it.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 hold-priority 4
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 hold-priority
```

secondary-priority setup-priority

Use this command to configure a setup priority value for the secondary-priority lsp.

In case of insufficient bandwidth, the user must remove any less important LSPs to free up bandwidth. This can be done by preempting one or more of the existing LSPs. The setup priority determines whether a new LSP that preempts an existing LSP may be established. The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the no parameter with this command to revert to the default setup priority value.

Command Syntax

```
secondary-priority <1-5> setup-priority <0-7>
no secondary-priority <1-5> setup-priority <0-7>
```

Parameters

`<1-5>`	Secondary Priority value.
`<0-7>`	Specify a value for hold priority.

Default

By default, setup value is 7 (the lowest).

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 setup-priority 4
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 setup-priority 4
```

secondary-priority label-record

Use this command to record all labels exchanged between RSVP enabled routers during the reservation setup process. This command records all labels exchanged for an LSP from the ingress to the egress, and helps with debugging.

Use the no parameter to turn off recording.

Command Syntax

```
secondary-priority <1-5> label-record
no secondary-priority <1-5> label-record
```

Parameters

`<1-5>`	Secondary Priority value.

Default

By default, label record is disabled for secondary-priority.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 label-record
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 label-record
```

secondary-priority hop-limit

Use this command to specify a limit of hops for a secondary-priority lsp.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the path, if a path has been configured. If the number of hops in the path exceed the hop-limit configured, no path messages are sent out and any existing session is torn down.

Use the no parameter to revert to the default hop-limit value.

Command Syntax

```
secondary-priority <1-5> hop-limit <1-255>
no secondary-priority <1-5> hop-limit <1-255>
```

Parameters

`<1-5>`	Secondary Priority value.
`<1-255>`	The number of acceptable hops.

Default

By default, hop limit is 255.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 hop-limit 123
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 hop-limit 123
```

secondary-priority bandwidth

Use this command to reserve the bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is set in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although label exchanges are possible.

Use the no parameter with this command to unset the configured bandwidth information.

Command Syntax

```
secondary-priority <1-5> bandwidth BANDWIDTH
no secondary-priority <1-5> bandwidth BANDWIDTH
```

Parameters

`<1-5>`	Secondary Priority value.
`BANDWIDTH`	<1-999>k for 1 to 999 kilobits/s <1-999>m for 1 to 999 megabits/s <1-100>g for 1 to 100 gigabits/s

Default

By default, bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
(config)# rsvp-trunk t1
(config-trunk)#secondary-priority 1 bandwidth 100m
(config)# rsvp-trunk t1
(config-trunk)# no secondary-priority 1 bandwidth 100m
```

secondary record

This command is used to enable recording of the route taken by path and resv messages to confirm the establishment of reservations and to identify errors. Routes are recorded by means of the route record object (RRO) in RSVP messages.

Use the no secondary record command to revert to the default settings.

Command Syntax

```
secondary record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary record
```

secondary retry-limit

Use this command to specify a retry count this RSVP Trunk.

If a session is in a nonexistent state due to the receipt of a path error message, it tries to recreate the LSP for the number of times specified by primary retry-limit. Although the same retry command controls both the trunk and the session, the retry-limit value affects only the session and not the trunk. If the trunk is in an incomplete state, the code keeps trying to bring it to a complete state, irrespective of the retry-limit value.

Use the `no` parameter to revert to the default retry-limit value.

Command Syntax

```
secondary retry-limit <1-65535>
no secondary retry-limit
```

Parameter

`<1-65535>`	The set number of times the system should try setting up the LSP

Default

By default, the retry-limit value is 0 so the trunk and session try to create the LSP indefinitely.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary retry-limit 256
```

secondary retry-timer

Use this command to specify a retry interval for an RSVP Trunk. When the ingress tries to configure an LSP and the setup fails due to the receipt of a path error message, the system waits for the time configure by this command before retrying the LSP setup process.

Use the `no` parameter to revert to the default.

Command Syntax

```
secondary retry-timer <1-600>
no secondary retry-timer
```

Parameter

`<1-600>`	Interval after which the system should retry setting up the LSP, in seconds

Default

By default, retry time is 30 seconds

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary retry-timer 12
```

secondary reuse-route-record

Use this command to use the updated route record list as an explicit route (with all strict nodes) when a path message is sent out at the next refresh.

An explicit route object (ERO) list contains the hops to be taken to reach the egress from the current LSR. If CSPF can not place an ERO with all strict routes, then this command helps modify the ERO after receiving resv messages. Future path messages have the ERO with all strict nodes, which identify each and every node to be traversed.

Use the `no` parameter to disable the use of the route record list as the explicit route.

Command Syntax

```
secondary reuse-route-record
no secondary reuse-route-record
```

Parameters

None

Default

By default, secondary reuse route record is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary reuse-route-record
```

secondary setup-priority

Use this command to configure a setup priority value for this trunk.

In case of insufficient bandwidth, the user must remove any less important LSPs to free up bandwidth. This can be done by preempting one or more of the existing LSPs. The setup priority determines whether a new LSP that preempts an existing LSP may be established. The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the `no` parameter with this command to revert to the default setup priority value.

Command Syntax

```
secondary setup-priority <0-7>
no secondary setup-priority
```

Parameters

`<0-7>`	The priority value

Default

By default, setup value is 7 (the lowest).

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary setup-priority 2
```

secondary traffic

Use this command to identify the traffic type for this RSVP Trunk.

Use the `no` parameter with this command to unset the configured traffic type.

Command Syntax

```
secondary traffic (guaranteed|controlled-load)
no secondary traffic
```

Parameters

`guaranteed` Guaranteed traffic

`controlled-load` Controlled load traffic

Default

Controlled load is the default traffic type.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#secondary traffic guaranteed
```

shutdown

Use this command to administratively disable a trunk. Execute this command to release the sessions of this trunk, and it only comes up once it is administratively enabled.

Use the `no` parameter to enable the trunk.

Command Syntax

```
shutdown
```

```
no shutdown
```

Parameters

None

Default

None

Command Mode

Trunk mode

Applicability

Introduced in OcNOS version 6.5.1.

Examples

The below example disable the trunk administratively:

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#shutdown
(config-trunk)#commit
```

The below example enable the trunk administratively:

```
#configure terminal
(config)#rsvp-trunk t1
(config-trunk)#no shutdown
(config-trunk)#commit
```

snmp restart rsvp

Use this command to restart SNMP in Resource Reservation Protocol -Traffic Engineering (RSVP-TE)

Command Syntax

```
snmp restart rsvp
```

Parameters

None

Default

By default, snmp restart rsvp is disabled

Command Mode

Configure mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#snmp restart rsvp
```

to A.B.C.D

Use this command to specify an IPv4 egress for an LSP. When configuring an LSP, you must specify the address of the egress router by using this command in the trunk node. An egress definition is a mandatory attribute; no RSVP session is created when an egress is not defined.

Use the `no` parameter with this command to unset the configured egress address.

Command Syntax

```
to A.B.C.D
no to
```

Parameters

None

Default

The operator must specify an egress for LSP initialization to begin.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk mytrunk
(config-trunk)#to 10.10.0.5
```

update-type

Use this command to change the method of updating attributes for sessions (primary/ secondary) for this trunk.

- If make-before-break is configured (default type), a new LSP is created for each attribute update. When the new LSP becomes operational, the original LSP is torn down.
- If break-before-make is configured, the existing LSP is torn down and restarted for each attribute update.

Use the `no` parameter with this command to remove an update type.

Command Syntax

```
update-type (make-before-break|break-before-make)
no update-type
```

Parameters

`make-before-break`
Make before break update

`break-before-make`
Break before make update

Default

By default, make-before-break types of updates are carried out.

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#update-type break-before-make

#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#update-type make-before-break
```

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CHAPTER 2 Fast Reroute Commands

This chapter describes the RSVP-TE Fast Reroute commands.

Note: Constrained Shortest Path First (CSPF) is mandatory for FRR to work.

default-frr-protection

Use this command to configure the default method of fast reroute protection when sender has not specified a method via FRR object but asked for local protection. This command is particularly useful with interop with Cisco as Cisco doesn't send FRR object in path message. By default, default FRR protection considered to be one-to-one in OcNOS and in case of interop with Cisco where default protection needed is facility, this command shall be configured on all OcNOS devices in the network.

Note: Having this command configured in one OcNOS device and not configured in other OcNOS device in the network will cause unpredictable behavior as RFC recommendation for merge node behavior of facility and one-to-one are different.

Note: This command is applicable only when path message contains local protection flag set but doesn't contain FRR object. When FRR object mentions protection type explicitly, this command is not applicable and also, if path message doesn't request local protection, then also this command is not applicable.

Command Syntax

```
default-frr-protection (one-to-one | facility)
no default-frr-protection
```

Parameters

`facility`	Facility Backup (Bypass) protection
`one-to-one`	One-to-One protection mechanism

Default

By default, if local protection requested but FRR object not available, one-to-one protection is considered.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 6.3.1.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)# default-frr-protection facility
(config-router)# commit
(config-router)# no default-frr-protection
(config-router)# commit
```

detour-identification

Use this command to set a path-specific detour LSP identification method, using the detour object.

Use the no parameter with this command to unset the detour LSP identification method.

Note: This command helps identify the backup LSP identification method for one-to-one protection only.

Command Syntax

```
detour-identification (path|sender-template)
no detour-identification
```

Parameters

`path`	Set a path-specific detour identification method
`sender-template`	Set a sender template-specific detour identification method

Default

By default, detour identification is sender template

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#detour-identification path

#configure terminal
(config)#router rsvp
(config-router)#detour-identification sender-template

#configure terminal
(config)#router rsvp
(config-router)#no detour-identification
```

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primary fast-reroute bandwidth

Use this command to set the detour LSP bandwidth.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to unset fast-reroute LSP bandwidth.

Command Syntax

```
primary fast-reroute bandwidth BANDWIDTH
no primary fast-reroute bandwidth BANDWIDTH
no primary fast-reroute BANDWIDTH
```

Parameter

BANDWIDTH	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

By default, primary fast reroute bandwidth is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute bandwidth 10000000
```

primary fast-reroute hold-priority

Use this command to set the hold-priority for a detour LSP.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to unset the detour LSP hold-priority.

Command Syntax

```
primary fast-reroute hold-priority <0-7>
no primary fast-reroute hold-priority (<0-7>|)
```

Parameter

`<0-7>`	Set the value for hold-priority

Default

By default, primary fast reroute hold priority is 0

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute hold-priority 3
```

primary fast-reroute hop-limit

Use this command to set the hop-limit for a detour LSP.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to unset the detour LSP hop-limit.

Command Syntax

```
primary fast-reroute hop-limit <1-255>
no primary fast-reroute hop-limit (<1-255>|)
```

Parameter

`<1-255>`	Set the number of hops

Default

By default, primary fast reroute hop limit is 255

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute hop-limit 25
```

primary fast-reroute node-protection

Use this command to set node protection.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to remove node protection.

Command Syntax

```
primary fast-reroute node-protection
no primary fast-reroute node-protection
```

Parameters

None

Default

By default, primary fast reroute node protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute node-protection
```

primary fast-reroute protection

Use this command to create an Fast Reroute backup and to set an LSP one-to-one protection or facility backup mechanism.

Note: Traffic switching of less than 50ms is not applicable for unknown unicast traffic received on edge nodes for VPLS services.

Use the `no` parameter with this command to remove LSP protection mechanism.

Parameters

None

Command Syntax

```
primary fast-reroute protection (one-to-one|facility)
no primary fast-reroute protection (one-to-one|facility)
```

Parameters

`one-to-one`	One-to-one protection
`facility`	Facility backup (bypass) protection"

Default

By default, primary fast reroute protection is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute protection one-to-one
```

primary fast-reroute setup-priority

Use this command to configure a setup-priority for the detour LSP.

Note: This command helps identify attributes of the FRR backup LSP for the one-to-one protection method.

Use the `no` parameter with this command to remove the detour LSP setup-priority.

Command Syntax

```
primary fast-reroute setup-priority <0-7>
no primary fast-reroute setup-priority (<0-7>|)
```

Parameter

<0-7>	Set a value for setup priority

Default

By default, primary fast reroute setup priority is 0

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary fast-reroute setup-priority 2
```

CHAPTER 3 Refresh Reduction Commands

This chapter describes the RSVP-TE Refresh Reduction commands:

- ack-send-timer
- ack-wait-timeout
- message-ack
- refresh-reduction
- rsvp ack-wait-timeout
- rsvp message-ack
- rsvp refresh-reduction

ack-send-timer

Use this command to configure the timer to send an acknowledgement message. Timer configuration increases the chances of piggy backing multiple acknowledgement messages but also adds delay in acknowledgment received by neighbor node. So, use this command with exact knowledge of optimum time.

Note: Configure this command with a value within the limit of ack-wait-timeout to avoid frequent timeout.

Command Syntax

```
ack-send-timer <1-5>
no ack-send-timer
```

Parameter

`<1-5>`	Value in seconds for acknowledgement send timer.

Default

By default, acknowledgement message is transmitted immediately without piggy-backing.

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 6.4.1.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)# ack-send-timer 1
(config-router)# commit
(config-router)# no ack-send-timer
(config-router)# commit
```

ack-wait-timeout

Use this command to configure the acknowledgement wait timeout for all RSVP-TE neighbors.

Use the `no` parameter with this command to revert to the default acknowledgement wait timeout.

Command Syntax

```
ack-wait-timeout <1-65535>
no ack-wait-timeout
```

Parameter

<1-65535>	Specify a value for the acknowledgement wait timeout in seconds. The default timeout value is 10 seconds.

Default

By default, ack wait timeout is 10 seconds

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#ack-wait-timeout 5

(config)#router rsvp
(config-router)#no ack-wait-timeout
```

message-ack

Use this command to enable message acknowledgment for all messages being sent to neighbors that are known to support refresh reduction.

Use the `no` parameter with this command to disable message acknowledgment for all messages being sent to neighbors.

Command Syntax

```
message-ack
no message-ack
```

Parameters

None

Default

By default, Message Acknowledgment is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#message-ack

(config)#router rsvp
(config-router)#no message-ack
```

refresh-reduction

Use this command to enable refresh reduction capability advertisement for all interfaces.

Use the no parameter with this command disable refresh reduction capability advertisement for all interfaces.

Command Syntax

```
refresh-reduction
no refresh-reduction
```

Parameters

None

Default

By default, Refresh reduction mechanism is enabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#refresh-reduction

(config)#router rsvp
(config-router)#no refresh-reduction
```

rsvp ack-wait-timeout

Use this command to configure the acknowledgment wait timeout for all neighbors detected via the specific interface.

Use the `no` parameter with this command to revert to the default acknowledgment wait timeout for the specified interface.

Command Syntax

```
rsvp ack-wait-timeout <1-65535>
no rsvp ack-wait-timeout
```

Parameters

`<1-65535>`	Specify a value for the acknowledgment wait timeout in seconds. The default timeout value is 10 seconds.

Default

By default, rsvp ack wait timeout is 10 seconds

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp ack-wait-timeout 5

(config)#interface eth0
(config-if)#no rsvp ack-wait-timeout
```

rsvp message-ack

Use this command to enable message acknowledgment for all messages being sent to the neighbors that have been detected via the specific interface.

Use the `no` parameter with this command to disable message acknowledgment for all messages being sent to the neighbors that have been detected via the specified interface.

Command Syntax

```
rsvp message-ack
no rsvp message-ack
```

Parameters

None

Default

By default, Message Acknowledgment is disabled

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp message-ack

(config)#interface eth0
(config-if)#no rsvp message-ack
```

rsvp refresh-reduction

Use this command to enable Refresh Reduction capability advertisement for a specific interface.

Use the `no` parameter with this command disable Refresh Reduction capability advertisement for the specified interface.

Command Syntax

```
rsvp refresh-reduction
no rsvp refresh-reduction
```

Parameters

None

Default

Refresh Reduction mechanism is enabled by default for all interfaces.

Command Mode

Interface mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#interface eth0
(config-if)#rsvp refresh-reduction

(config)#interface eth0
(config-if)#no rsvp refresh-reduction
```

CHAPTER 4 Facility Backup Commands

This chapter describes the RSVP-TE bypass commands for facility backup protection

- RSVP Auto Bypass Commands
- backup-bw-type
- bandwidth
- bypass-lsp-addr-query-interval
- cspf-retry-limit
- cspf-retry-timer
- filter
- hold-priority
- hop-limit
- label-record
- no record
- path
- preemption-type
- record
- retry-limit
- retry-timer
- reuse-route-record
- rsvp-bypass
- setup-priority
- shutdown
- to A.B.C.D
- traffic

backup-bw-type

Use this command to select the bypass trunk bandwidth support type.

Bypass trunks of dedicated bandwidth type will serve only bandwidth protections requested LSPs. The total bandwidth requirement of served LSPs will be less than or equal to the bandwidth configured on the bypass trunk. If an LSP with bandwidth protection and higher setup priority requests protection and bypass doesn't have sufficient bandwidth available, then LSPs with lower hold priority will be preempted to serve the LSP with higher setup priority.

Use the `no` parameter to remove configured backup bandwidth type.

Command Syntax

```
backup-bw-type (dedicated | best-effort)
no backup-bw-type
```

Parameters

`dedicated`	Dedicated backup bandwidth support
`best-effort`	Best effort backup bandwidth support

Default

best-effort

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#backup-bw-type dedicated
```

bandwidth

Use this command to reserve the bypass bandwidth in bits per second for the current trunk.

Each LSP has an associated bandwidth attribute. The bandwidth value is included in the sender's RSVP Path message and specifies the bandwidth to be reserved for the LSP. It is specified in bits per second, with a higher value indicating a greater user traffic volume. A zero bandwidth reserves no resources, although exchanges labels.

Use the `no` parameter to remove configured bandwidth information.

Command Syntax

```
bandwidth BANDWIDTH
no bandwidth BANDWIDTH
no bandwidth
```

Parameter

`BANDWIDTH`	<1-999>k for 1 to 999 kilobits/s
	<1-999>m for 1 to 999 megabits/s
	<1-100>g for 1 to 100 gigabits/s

Default

The default bandwidth is 0 bits per second, which allows data to flow through but does not reserve bandwidth.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#bandwidth 100m
(config-bypass)#no bandwidth
```

bypass-lsp-addr-query-interval

Use this command to set the interval at which bypass trunk must query CSPF for LSP address. This mechanism ensures to update bypass trunk LSP addresses regularly so that, it can verify regularly if it can protect any LSP requesting protection.

Use the `no` parameter with this command to reset the interval to default value.

Note: Reducing interval to lower values may impact performance.

Command Syntax

```
bypass-lsp-addr-query-interval <10-60>
no bypass-lsp-addr-query-interval
```

Parameter

`<10-60>`	Set interval of bypass trunk querying LSP address

Default

By default, interval is set to 60 seconds.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)# bypass-lsp-addr-query-interval 50
```

cspf-retry-limit

Use this command to specify the number of retries that CSPF should carry out for a request received from RSVP.

Use the `no` parameter with this command to disable this configuration.

Command Syntax

```
cspf-retry-limit <1-65535>
no cspf-retry-limit
```

Parameter

`<1-65535>`	Set the number of times CSPF should retry for this LSP

Default

By default, retry-limit is 0 which means infinite retry.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#cspf-retry-limit 535

(config)#rsvp-bypass bp1
(config-bypass)#no cspf-retry-limit
```

cspf-retry-timer

Use this command to specify the time between each retry that CSPF might carry out for a request received from RSVP. Use the no parameter with this command to disable this configuration.

Command Syntax

```
primary cspf-retry-timer <1-600>
no primary cspf-retry-timer
```

Parameter

`<1-600>`	Timeout between successive retries, in seconds

Default

By default, retry-timer is 0

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#cspf-retry-timer 45

(config)#rsvp-bypass bp1
(config-bypass)#no cspf-retry-timer
```

filter

Use this command to set the filter to the fixed or shared style for an LSP.

- The shared filter style identifies a shared reservation environment. It creates a single reservation into which flows from all senders are mixed.
- The fixed filter style designates a distinct reservation. A distinct reservation request is created for data packets from a particular sender. The fixed filter style is also used style to prevent rerouting of an LSP and to prevent another LSP from using this bandwidth.

Use the `no` parameter to reset the configured filter to the default.

Command Syntax

```
filter fixed
no filter
```

Parameters

`fixed`	Use a fixed filter for this LSP

Default

By default, bypass filter is shared-explicit.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#filter fixed
```

hold-priority

Use this command to configure the hold priority value for the selected bypass trunk. In case of insufficient bandwidth, remove less important existing LSPs to free up a portion of the bandwidth. This can be done by preempting one or more of the signaled LSPs. Hold priority determines the degree to which an LSP holds onto its reservation for a session after the LSP has been configured successfully. When the hold priority is high, the existing LSP is less likely to give up its reservation.

Use the `no` parameter to reset the trunk to the default hold-priority value.

Command Syntax

```
hold-priority <0-7>
no hold-priority
```

Parameters

`<0-7>`	Set a hold priority for the bypass LSP

Default

The default hold-priority value is 0, which is the highest. Once a session is configured with a hold priority of 0, no other session can preempt it.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#hold-priority 2
```

hop-limit

Use this command to specify a limit of hops for an RSVP bypass trunk. Hop-limit data is sent to the CSPF server if CSPF is used.

Upon configuration of an arbitrary hop-limit, the hop-limit is compared with the number of hops configured in the bypass path, if a bypass path has been configured. If the number of hops in the bypass path exceeds the hop-limit configured, no Path messages are sent, and any existing session is torn down. If no bypass path is configured, the bypass trunk is processed normally and Path messages are sent.

Use the `no` parameter to reset the bypass trunk to the default hop-limit value.

Command Syntax

```
hop-limit <1-255>
no hop-limit
```

Parameters

`<1-255>`	Set the number of acceptable hops for the LSP

Default

By default, bypass hop limit is 255

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#hop-limit 23
```

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label-record

Use this command to record all labels exchanged between RSVP-enabled routers during the reservation setup process.

Use the `no` parameter with this command to turn off recording.

Command Syntax

```
label-record
no label-record
```

Parameters

None

Default

By default, bypass label record is disabled

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#label-record
```

no record

Use this command to disable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means of the Route Record Object (RRO) in RSVP messages.

Use the `record` command to return to the default settings.

Command Syntax

```
no record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#no record
```

path

Use this command to specify an RSVP path to be used. The PATHNAME in this command is the string (name) used to identify an RSVP path defined for the node (refer to rsvp-path command).

Use the `no` parameter with this command to remove a configured RSVP path.

Command Syntax

```
path PATHNAME
no path
```

Parameters

PATHNAME	The name of the path to use

Default

By default, bypass path is disabled

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#path mypath
```

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preemption-type

Use this command to configure preemption type which decides the criteria to be considered in case of preemption.

Use the `no` parameter to remove configured preemption type.

Command Syntax

```
preemption-type (less-lsp-preempted | less-unused-bandwidth)
no preemption-type
```

Parameters

`less-lsp-preempted`	Set preemption type to minimize number of LSPs preempted
`less-unused-bandwidth`	Set preemption type to ensure less bypass bandwidth unused

Default

By default, preemption type is set to less-lsp-preempted.

Command Mode

Router mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#router rsvp
(config-router)#preemption-type less-unused-bandwidth
```

record

Use this command to enable recording of the route taken by Path and Reservation Request (Resv) messages to confirm establishment of reservations and identify errors. Routes are recorded by means or the Route Record Object (RRO) in RSVP messages.

Use the `no record` command to disable recording of routes.

Command Syntax

```
record
```

Parameters

None

Default

By default, routes are recorded

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#record
```

retry-limit

Use this command to specify a retry count this RSVP bypass Trunk.

If a session is in a nonexistent state due to a path error message, the system tries to recreate the LSP for the number of times specified by the retry-limit command.

Although the same retry command controls both the trunk and the session, the retry-limit value affects only the session and not the trunk. If the trunk is in an incomplete state, the code keeps trying forever to bring it to a complete state regardless of the retry-limit value.

Use the `no` parameter with this command to revert to the default retry-limit value.

Command Syntax

```
retry-limit <1-65535>
no retry-limit
```

Parameter

`<1-65535>`	The set number of times the system should try setting up the LSP

Default

By default, the retry-limit value is 0, and the trunk and session try to create the LSP indefinitely.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#retry-limit 256
```

retry-timer

Use this command to specify a retry interval for an RSVP bypass Trunk. When an ingress node tries to configure an LSP and the setup fails due to the receipt of a Path Error message, the system waits for the time configured with this command, before retrying the LSP setup process.

Use the `no` parameter with this command to revert to the default retry-time value.

Command Syntax

```
retry-timer <1-600>
no retry-timer
```

Parameters

`<1-600>`	Time in seconds after which the system should retry setting up the LSP

Default

By default, retry-timer value is 30 seconds.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#retry-timer 12
```

reuse-route-record

Use this command to use the updated Route Record List as an Explicit Route (with all strict nodes) when a path message is sent out at the next refresh.

The ERO list contains the hops to be taken to reach the egress from the current LSR. If CSPF is not available, to place an ERO with all strict routes, use this command to modify the ERO after receiving the Resv message. The future Path messages have the ERO with all strict nodes, identifying each and every node to be traversed.

Use the `no` parameter with this command to disable the use of the Route Record List as the explicit route.

Command Syntax

```
reuse-route-record
no reuse-route-record
```

Parameters

None

Default

By default, reuse route record is disabled

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#reuse-route-record
```

rsvp-bypass

Use this command to create a new RSVP bypass trunk. When the bypass trunk is created, the attributes required to configure an explicitly-routed or traditionally-routed LSP are set. Once a trunk is configured with the required attributes, an RSVP bypass session (and PSB) is created for this trunk, which enables the exchange of messages and completes the LSP setup.

This command also modifies an existing RSVP path to configure an explicitly-routed or traditionally-routed LSP.

Use the `no` parameter with this command to remove an RSVP bypass trunk and all configured attributes.

Note: The RSVP bypass' name (BYPASSNAME) is limited to 32 characters.

Command Syntax

```
rsvp-bypass BYPASSNAME
no rsvp-bypass BYPASSNAME
```

Parameters

`BYPASSNAME`	Name to use for the bypass trunk

Default

By default, `rsvp bypass trunk` is disabled

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

The command prompt changes from `config` to `config-bypass` as illustrated below:

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#
```

setup-priority

Use this command to configure a setup priority value for a trunk. In case of insufficient bandwidth, users must remove less important LSPs to free up the bandwidth. This can be done by preempting one or more of the existing LSPs. The primary setup priority determines if a new LSP can preempt an existing LSP.

The setup priority of the new LSP must be higher than the hold priority of an existing LSP for the existing LSP to be preempted. Note that for a trunk, the setup priority should not be higher than the hold priority.

Use the `no` parameter with this command to revert to the default primary setup priority value.

Command Syntax

```
setup-priority <0-7>
no setup-priority
```

Parameters

`<0-7>`	Set the priority value

Default

By default, setup priority is 7, which is the lowest.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#setup-priority 2
```

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shutdown

Use this command to administratively disable a bypass trunk. Execute this command to release the bypass session of this trunk, and it only comes up once it is administratively enabled.

Use the `no` parameter to enable the trunk.

Command Syntax

```
shutdown
no shutdown
```

Parameters

None

Default

None

Command Mode

Bypass mode

Applicability

Introduced in OcNOS version 6.5.1.

Examples

The below example disable the trunk administratively:

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#shutdown
(config-bypass)#commit
```

The below example enable the trunk administratively:

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#no shutdown
(config-bypass)#commit
```

to A.B.C.D

Use this command to specify an IPv4 egress for a bypass LSP. When configuring an LSP, you must specify the address of the egress router by using this command in the bypass node. An egress definition is a mandatory attribute; no RSVP session is created when an egress is not defined.

Use the `no` parameter with this command to unset the configured egress address.

Command Syntax

```
to A.B.C.D
no to
```

Parameters

None

Default

The operator must specify an egress for LSP initialization to begin.

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#to 10.10.0.5
```

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traffic

Use this command to specify the traffic type for this RSVP bypass Trunk.

Use the `no` parameter with this command to reset the configured traffic type.

Command Syntax

```
traffic (guaranteed|controlled-load)
no traffic
```

Parameters

`controlled-load`	Controlled loaded traffic
`guaranteed`	Guaranteed traffic

Default

By default, primary traffic type is controlled-load

Command Mode

Bypass mode

Applicability

This command was introduced in OcNOS version 3.0.

Examples

```
#configure terminal
(config)#rsvp-bypass bp1
(config-bypass)#traffic guaranteed
```

CHAPTER 5 Differentiated Services Commands

This chapter describes the RSVP Differentiated Services (DiffServ) commands.

map-route A.B.C.D

Use this command to map a IPv4 prefix route onto a trunk. This route is to be used for packets that are mapped to a specific RSVP trunk.

Use the `no` parameter with this command for unmapping routes from specified trunks.

Note: Do not configure the local address as a map route, as explicit validation is not done. The wrong configuration may impact traffic.

Command Syntax

```
map-route A.B.C.D A.B.C.D
map-route A.B.C.D A.B.C.D CLASS
map-route A.B.C.D/M
map-route A.B.C.D/M CLASS
no map-route A.B.C.D A.B.C.D
no map-route A.B.C.D A.B.C.D CLASS
no map-route A.B.C.D/M
no map-route A.B.C.D/M CLASS
```

Parameters

`A.B.C.D`	Specify the IPV4 address to be mapped.
`A.B.C.D`	Specify a mask to be applied to the address being mapped.
`A.B.C.D/M`	Specify the IPV4 address to be mapped, with mask.
`CLASS`	Specify the DiffServ Class Name (for example, `be`, `ef` etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.

Default

By default, map route A.B.C.D is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 1.1.2.2/24 be
```

map-route X:X::X:X

Use this command to map a IPv6 prefix route onto a trunk. This route is to be used for packets that are mapped to a specific RSVP trunk.

Use the `no` parameter with this command for unmapping routes from specified trunks.

Command Syntax

```
map-route X:X::X:X X:X::X:X
map-route X:X::X:X X:X::X:X CLASS
map-route X:X::X:X/M
map-route X:X::X:X/M CLASS
no map-route X:X::X:X X:X::X:X
no map-route X:X::X:X X:X::X:X CLASS
no map-route X:X::X:X/M
no map-route X:X::X:X/M CLASS
```

Parameters

`X:X::X:X`	Specify the IPV6 address to be mapped.
`X:X::X:X`	Specify a mask to be applied to the address being mapped.
`X:X::X:X/M`	Specify the IPV6 address to be mapped, with mask.
`CLASS`	Specify the DiffServ Class Name (for example, `be`, `ef` etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.

Default

By default, map route X:X::X:X is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#map-route 1.1.2.2/24 be
```

override-diffserv

Use this command to enable the Differentiated Services (Diff-Serv) override configuration.

If a Path message is received without a Diff-Serv object by a Diff-Serv enabled node, it can be interpreted either as a request for an E-LSP (EXP-Inferred-PSC LSP) or as a request for Non-Diff-Serv LSP. This command supports the override option and when configured, the LSR interprets a path message without a Diff-Serv object as a request for Non-Diff-Serv LSP.

Use the `no` parameter with this command disable this feature.

Command Syntax

```
override-diffserv
no override-diffserv
```

Parameters

None

Default

By default, override diffserv is disabled

Command Mode

Router mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#configure terminal
(config)#router rsvp
(config-router)#override-diffserv
```

primary class-to-exp-bit

Use this command to configure a primary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the `no` parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
primary class-to-exp-bit CLASS <0-7>
no primary class-to-exp-bit CLASS <0-7>
```

Parameters

`CLASS`	Specify the DiffServ Class Name (for example, be, ef etc.) used for selecting incoming IP packets to be mapped to a specified RSVP trunk.
`<0-7>`	Exp bit which is to be mapped to this PHB.

Default

By default, primary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary class-to-exp-bit af12 3

(config)#rsvp-trunk T1
(config-trunk)#no primary class-to-exp-bit af12 3
```

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primary elsp-signaled

Use this command to configure a primary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface.

The classes 1 to 7 are optional parameters that can be selected from node level PHB-EXP (Per-Hop Behavior) mapping as PHBs, which will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
primary elsp-signaled
primary elsp-signaled CLASS1
primary elsp-signaled CLASS1 CLASS2
primary elsp-signaled CLASS1  CLASS2 CLASS3
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4 CLASS5
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
primary elsp-signaled CLASS1  CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no primary elsp-signaled
```

Parameter

`CLASS<0-7>`	Diffserv class alias. e.g.: be, ef, af11, etc.

Default

By default, primary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary elsp-signaled cs2 cs5 cs6

(config)#rsvp-trunk T1
(config-trunk)#no primary elsp-signaled
```

primary llsp

Use this command to configure a primary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
primary llsp CLASS
no primary llsp
```

Parameters

CLASS<0-7>	Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, primary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#primary llsp cs4

(config)#rsvp-trunk T1
(config-trunk)#no primary llsp
```

secondary map class

Use this command to configure a secondary PHB-EXP (Per-Hop Behavior-Experimental) mapping to be used by an E-LSP (EXP-Inferred-PSC LSP). This mapping is different from the node level PHB-EXP mapping.

Use the no parameter with this command to remove a PHB-EXP mapping configuration from current E-LSP PHB-EXP mapping.

Command Syntax

```
secondary map class-to-exp-bit CLASS  <0-7>
no secondary map class-to-exp-bit CLASS  <0-7>
```

Parameters

`CLASS`	Diff-Serv class (queue) mapped to the particular PHB.
	Diffserv class alias e.g: be, ef, af11, etc.
`<0-7>`	Exp bit that is to be mapped to this PHB.

Default

By default, secondary map class is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary class-to-exp-bit cs4 3

(config)#rsvp-trunk T1
(config-trunk)#no secondary class-to-exp-bit cs4 3
```

secondary elsp-signaled

Use this command to configure a secondary Diff-Serv (Differentiated Services) explicitly signaled E-LSP (EXP-Inferred-PSC LSP) interface. The classes 1 to 7 are optional parameters can be selected from the node level PHB-EXP (Per-Hop Behavior) mapping as PHBs. They will then be used for an E-LSP. If you do not specify a class with this command, all classes will be selected for the E-LSP.

Use the no parameter with this command to remove the configuration.

Command Syntax

```
secondary elsp-signaled
secondary elsp-signaled CLASS1
secondary elsp-signaled CLASS1 CLASS2
secondary elsp-signaled CLASS1 CLASS2 CLASS3
secondary elsp-signaled  CLASS1 CLASS2 CLASS3 CLASS4
secondary elsp-signaled  CLASS1 CLASS2 CLASS3 CLASS4 CLASS5
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6
secondary elsp-signaled CLASS1 CLASS2 CLASS3 CLASS4 CLASS5 CLASS6 CLASS7
no secondary elsp-signaled
```

Parameters

`CLASS<0-7>`	Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary elsp signaled is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary elsp-signaled class cs3 cs6 cs2 cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary elsp-signaled
```

secondary llsp

Use this command to configure a secondary Differentiated Services Label-Only-Inferred-PSC (Diff-Serv L-LSP) interface, which will use Diff-Serv Class as its PHB Scheduling Class (PSC).

Use the no parameter with this command to remove the Diff-Serv L-LSP configuration.

Command Syntax

```
secondary llsp CLASS
no secondary llsp
```

Parameters

`CLASS<0-7>`	Diffserv class alias. e.g: be, ef, af11, etc.

Default

By default, secondary llsp is disabled

Command Mode

Trunk mode

Applicability

This command was introduced before OcNOS version 1.3.

This command is not available on QUMRAN devices.

Example

```
#configure terminal
(config)#rsvp-trunk T1
(config-trunk)#secondary llsp class cs5

(config)#rsvp-trunk T1
(config-trunk)#no secondary llsp
```

show rsvp diffserv-info

Use this command to display node level Differentiated Services (Diff-Serv) configuration information. This information includes the node level PHB-EXP mapping configured for ELSP-signaled LSP.

Command Syntax

```
show rsvp diffserv-info
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following is a sample output of the `show rsvp diffserv-info` command.

```
#show rsvp diffserv-info
CLASS-EXP mapping:
CLASS    DSCP_value
 c5  101000 0
 be  000000 1
 cs1 001000 2
 cs3 011000 3
 cs2 010000 4
 cs4 100000 5
 cs6 110000 6
 cs7 111000 7
Table 5-1 explains the show command output fields.
```

Table 5-1: show rsvp diffserv-info output fields

Field	Description
CLASS	MPLS class type that corresponds to the DiffServ traffic engineering class.
EXP_value	Exp value is initialized at the ingress routing device only and overrides the rewrite configuration established for that forwarding class.

CHAPTER 6 RSVP Multipath Commands

This chapter is a reference for RSVP Multipath commands:

description

Use this command to add a description to the multipath group or update an existing description.

Use the `no` parameter to remove the description.

Command Syntax

```
description LINE
no description
```

Parameter

`LINE`	Line describing the purpose of RSVP multipath Group

Default

By default, description is empty.

Command Mode

Multipath mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#rsvp-multipath mygroup
(config-multipath)# description "For example purpose"
(config-multipath)# no description
```

multipath-group

Use this command to configure a multipath group on the RSVP trunk. When multipath group is configured on the trunk, trunk will become member of multipath group.

Use the `no` parameter to remove multipath group from RSVP trunk.

Command Syntax

```
multipath-group GROUPNAME
no multipath-group
```

Parameter

GROUPNAME	Name of the multipath group

Default

By default, parameter is not configured.

Command Mode

Trunk mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#rsvp-trunk to_dest1
(config-trunk)# multipath-group mygroup
(config-trunk)# no multipath-group
```

rsvp-multipath

Use this command to create a new multipath group or enter the existing group to update any group parameter.

Use the `no` parameter with this command to remove an RSVP multipath group.

Command Syntax

```
rsvp-multipath GROUPNAME
no rsvp-multipath GROUPNAME
```

Parameter

GROUPNAME	Name of the multipath group

Default

By default, rsvp multipath is not configured.

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

The command prompt changes from config to config-multipath as illustrated below:

```
#configure terminal
#(config)#rsvp-multipath mygroup
#(config-multipath)#exit
#(config)#no rsvp-multipath mygroup
```

to A.B.C.D

Use this command to specify an IPv4 egress to a multipath group. When configuring a multipath group, you must specify the address of the egress router by using this command. An egress definition is a mandatory attribute; multipath group is not allowed to be configured on RSVP trunks when an egress is not defined.

Use the no parameter to remove the IPv4 egress address from multipath group.

Command Syntax

```
to A.B.C.D
no to
```

Parameter

A.B.C.D	IPv4 address of multipath group destination

Default

By default, parameter is not configured.

Command Mode

Multipath mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#configure terminal
(config)#rsvp-multipath mygroup
(config-multipath)# to 3.3.3.3
(config-multipath)# no to
```

show mpls counters rsvp multipath-name

Use this command to get traffic statistics over member trunks of multipath group.

Note: Qumran devices require hardware statistics profiles to be enabled explicitly for traffic statistics to be active. For tunnel statistics 'tunnel-lif' statistics profiles need to be enabled and system needs to be reloaded to take effect. Please see the `hardware-profile statistics` command in the *OcNOS Configuration Guide* for details.

Note: This statistic is not an explicit count of traffic over a multipath group. This statistic is collected over multipath members individually and any traffic individually carried by multipath members also counted under this output.

Command Syntax

```
show mpls counters rsvp multipath-name (NAME|)
```

Parameter

`NAME`	RSVP multipath group name

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#show  mpls counters rsvp multipath-name test
Tunnel-id 5001 Extended Tunnel-ID 1.1.1.1 Egress 2.2.2.2
 lsp-name : t1-Primary                                  [Ingress]
 lsp-ingress : 1.1.1.1          lsp-id : 2201
 Rx pkts : n/a                  Rx bytes : n/a
 Tx pkts : 3776248              Tx bytes : 5671925998

Tunnel-id 5002 Extended Tunnel-ID 1.1.1.1 Egress 2.2.2.2
 lsp-name : t2-Primary                                  [Ingress]
 lsp-ingress : 1.1.1.1          lsp-id : 2202
 Rx pkts : n/a                  Rx bytes : n/a
 Tx pkts : 3776250              Tx bytes : 5671927500
```

show mpls rsvp-multipath

Use this command to display forwarder level information for a multipath group or all multipath groups.

Command Syntax

```
show mpls rsvp-multipath (NAME|)
```

Parameter

NAME	RSVP multipath group name

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
# show mpls rsvp-multipath
Codes: > - installed FTN, * - selected FTN, t - tunnel, R - RSVP-TE FTN

Multipath Name : mp1,  ID : 101,  Nhlfe Ix : 2
  Active member count : 2,  FEC : 2.2.2.2/32
  Active member details :
  -----------------------
Index  Code    FTN-ID  Nhlfe-ID  Tunnel-id  Pri  LSP-Type     Out-Label  Out-Intf  ELC  Nexthop
1      R(t)>   1       1         5002       Yes  LSP_DEFAULT  24320      xe31      No   31.1.1.2
2      R(t)>   2       3         5001       Yes  LSP_DEFAULT  24321      xe11      No   11.1.1.2
```

show rsvp multipath

Use this command to display information for a multipath group or all multipath groups.

Command Syntax

```
show rsvp multipath (NAME|)
```

Parameter

`NAME`	RSVP multipath group name

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#show rsvp multipath

RSVP-multipath Name : mp1,  ID : 101
  Description : "multipath group from R1 to R2"
  Member count : 3,  Egress : 2.2.2.2/32
  Member details :
  ----------------
  Trunk-ID   Trunk-name                    Status
  5001       to_R2_1                       active
  5002       to_R2_2                       active
  5003       to_R2_3                       inactive

RSVP-multipath Name : mp2,  ID : 102
  Member count : 0,  Egress : 3.3.3.3/32

RSVP-multipath Name : mp3,  ID : 103
  Member count : 0,  Egress : N/A
```

show running-config rsvp-multipath

Use this command to check configuration details of multipath groups.

Command Syntax

```
show running-config rsvp-multipath (NAME|)
```

Parameter

NAME	Name of the multipath group

Command Mode

Exec mode and Privilege Exec mode

Applicability

This command was introduced in OcNOS version 5.0.

Examples

```
#show running-config rsvp-multipath
!
rsvp-multipath mp1
 description "multipath group from R1 to R2"
 to 2.2.2.2
!
rsvp-multipath mp2
 to 3.3.3.3
!
rsvp-multipath mp3
!
!
```

CHAPTER 7 Show Commands

This chapter describes the RSVP-TE show commands.

show debugging rsvp

This command displays the status of the options selected by the `debug RSVP` command.

Command Syntax

```
show debugging rsvp
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show debugging rsvp
NSM debugging status:
  RSVP event debugging is on
  RSVP packet debugging is on
  RSVP incoming packet debugging is on
  RSVP outgoing packet debugging is on
  RSVP hexadecimal dump debugging is on
#
```

Table 7-2 explains the show command output fields.

Table 7-2: show debugging rsvp output fields

Field	Description
NSM debugging status	Debugging is enabled or disabled on a per-interface basis, using the commands.

show rsvp

Use this command to display data about the RSVP daemon.

Command Syntax

```
show rsvp
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp
RSVP Version                    : 1
Process uptime                  : 8 minutes
RSVP Refresh Reduction          : Enabled
RSVP Message Acknowledgement    : Disabled
Bundle Send                     : Disabled
NSM Connection                  : Up
CSPF Connection                 : Up
CSPF usage                      : Enabled
RSVP Refresh Timer              : 5
Keep Multiplier                 : 3
Acknowledgement Await Timeout   : 10
Explicit-Null For Direct Conn   : Disabled
Local Protection                : Disabled
Hello Receipt                   : Disabled
Hello Interval                  : 2
Hello Timeout                   : 10
Loop detection                  : Enabled (all interface)
Override Diffserv               : Disabled
Ingress                         : 1.1.1.1
Penultimate Hop Popping         : Enabled
Refresh PATH msg parsing        : Enabled
Refresh RESV msg parsing        : Enabled
Detour identification           : Sender-Template

#
```

Table 7-3 explains the show command output fields.

Table 7-3: show rsvp output fields

Field	Description
RSVP Version	Version number associated with the RSVP ingress route.
Process uptime	Duration of the process running time.
RSVP Refresh Reduction	Measure of processing over head requests of refresh messages. Refresh reduction detail extensions improve routing device performance by reducing the process overhead, thus increasing the number of LSPs a routing device can support.
RSVP Message Acknowledgement	Acknowledge message for refresh reductions.
Bundle Send	Disables sending of Bundle Messages for a system.
NSM Connection	The Network Services Module (NSM) sends unsolicited messages to, or receives unsolicited messages from, the QoS (quality of service) module.
CSPF Connection	NSM passes the information to CSPF.
CSPF usage	CSPF finds the shortest path toward the LSP’s egress router, taking into account explicit-path constraints.
RSVP Refresh Timer	Time interval used to generate periodic RSVP messages.
Keep Multiplier	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Acknowledgment Await Timeout	The router that initiates the acknowledgment messages for an RSVP session waits for the timeout.
Explicit-Null For Direct Conn	Advertise label 0 to the egress routing device of an LSP. Explicit null: enabled or disabled.
Local Protection	A local repair mechanism is in use to maintain this tunnel.
Hello Receipt	To exchange Hello messages among neighbors.
Hello Interval	Frequency at which RSVP hellos are sent on this interface (in seconds).
Hello Timeout	RSVP Hello State Timer feature detects when a neighbor is down and triggers faster state timeout.
Loop detection	Loop back Detection (LBD) provides protection against loops by transmitting loop protocol packets out of ports where loop protection has been enabled.
Override Diffserv	Diffserv helps to carry the EXP-to-PHB mapping for signaled E-LSP or the PSC value for L-LSP.
Ingress	Information about ingress RSVP sessions.
Penultimate Hop Popping	Removes the label one hop before its destination.
Refresh PATH msg parsing	Refresh message supports the refreshing of RSVP state without the transmission of conventional Path messages.
Refresh RESV msg parsing	Refresh message supports the refreshing of RSVP state without the transmission of conventional Resv messages.
Detour identification	Detours are calculated to avoid the immediate downstream link and node.

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show rsvp admin-groups

Use this command to display all known administrative groups configured through the NSM for the system.

Command Syntax

```
show rsvp admin-groups
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

This is a sample output showing four administrative groups configured through NSM.

```
#show rsvp admin-groups
 Admin group detail:
  Value of 0 associated with admin group 'a'
  Value of 1 associated with admin group 'b'
  Value of 2 associated with admin group 'c'
  Value of 3 associated with admin group 'd'
#
```

Table 7-4 explains the show command output fields.

Table 7-4: show rsvp admin-groups output field

Field	Description
Admin group detail	Administrative groups details which implements the link coloring of resource classes.

show rsvp bypass

Use this command to display bypass session related information for configured bypass LSPs.

Command Syntax

```
show rsvp bypass
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass
Ingress RSVP:
To              From            Tun-ID   LSP-ID   LSPName                         State Uptime    Rt  Style  Labelin  Labelout
172.31.54.4      172.31.54.1     5001     2201     BYPASS2-172.31.222.19-Bypass    UP    02d15h11m 1 1 SE     -        52516
172.31.54.2      172.31.54.1     5002     2202     BYPASS3-172.31.222.9-Bypass     UP    02d15h11m 1 1 SE     -        0
172.31.54.2      172.31.54.1     5003     2203     BYPASS4-172.31.222.7-Bypass     UP    02d15h11m 1 1 SE     -        0
172.31.53.18   172.31.54.1      5004      2204     BYPASS5-172.31.189.179-Bypass  UP    02d15h11m 1 1 SE     -        52501
```

show rsvp bypass detail

Use this command to display bypass session related information in detail for all configured bypass LSPs or the bypass session with specified bypass tunnel name.

Command Syntax

```
show rsvp bypass (BYPASSNAME | detail)
```

Parameters

`BYPASSNAME`	Bypass tunnel name
`detail`	Detailed information of all configured bypass sessions

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass BYPASS2-172.31.222.19
Ingress (Bypass)
172.31.54.4
  From: 172.31.54.1, LSPstate: Up, LSPname: BYPASS2-172.31.222.19-Bypass
  Ingress FSM state: Operational
  Establishment Time: 0s 324ms
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: OSPF
  IGP-Shortcut: Disabled, LSP metric: 1
  LSP Protection: None
  Bypass trunk bandwidth type: Best-effort
   Label in: -,  Label out:    52516,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2201, Ext-Tunnel Id: 172.31.54.1
  Bind value: 0, Oper state: NA, Alloc mode: NA
  Downstream: 172.31.222.25, po22
  Path refresh: 30 seconds (RR enabled) (due in 12409 seconds)
  Resv lifetime: 157 seconds (due in 130 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: none
  Exclude Link: 172.31.222.19
  Session Explicit Route Detail :
   172.31.222.25/32 strict
   172.31.180.3/32 strict
   172.31.180.4/32 strict
  Record route:
   -------------------------------------------------------------
   IP Address        Label
   -------------------------------------------------------------
```

```
 <self>
 172.31.222.25
 172.31.180.3
 172.31.180.4
Style: Shared Explicit Filter
Traffic type: controlled-load
Minimum Path MTU: 9174
Current Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Last Signaled Error:
  Code : None, Value : None
  Originated Node : None, Recorded Time : N/A
Trunk Type: mpls
Total LSP protected : 0, Bandwidth in use : 0
```

show rsvp bypass lsp-address-list

Use this command to display address details of every node of a bypass session shown as merge node detail for egress node of bypass session and transit node detail for transit node details of bypass session.

Command Syntax

```
show rsvp bypass (BYPASSNAME|) lsp-address-list
```

Parameters

BYPASSNAME	(Optional) Bypass tunnel name

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass BYPASS2-172.31.222.19 lsp-address-list
Bypass trunk: BYPASS2-172.31.222.19

Merge Point Router ID: 172.31.54.4

Number of Merge Point IP addresses: 6
IP address:
  172.31.222.22    172.31.180.4     172.31.222.19    172.31.222.27
  172.31.222.31    172.31.186.4

Number of Transit Point IP addresses: 9
IP address:
  172.31.54.3      172.31.222.23    172.31.222.30    172.31.180.2
  172.31.222.25    172.31.186.20    172.31.33.120    172.31.180.3
  172.31.180.5

LSP address query interval: 60 seconds, next retry in: 27 seconds
```

show rsvp bypass protected-lsp-list

Use this command to display the list of sessions protected by a bypass session and match code provides the details bypass is a perfect match or any constraint compromised.

Note: Match code 0 is an indication of perfect match i.e. all constraint of protected session matched. i.e. If protected session asked for node protection, then bypass provides perfect node protection by merging exactly at next to next hop node. If protected session asked for bandwidth protection, bypass provides bandwidth protection. In case of PHP node, even when node protection is requested by protected session, it is not applicable and node protection request is not applicable on PHP node. Thus, a bypass providing link protection with other criteria matching is considered as perfect match.

Note: If a bypass protected session requested for link protection but it is mapped to a bypass node protection, then it is not a perfect match. Match code will be 4 in that case.

Note: When bandwidth protection is requested, highest importance of bypass mapping given to bandwidth protection. When bandwidth protection cannot be provided, then the remaining constraints given importance.

Command Syntax

```
show rsvp bypass (BYPASSNAME|) protected-lsp-list
```

Parameters

BYPASSNAME	Bypass tunnel name

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp bypass protected-lsp-list
Match Code: 0 - Perfect match (all criteria matching), 1 - Bandwidth protection miss, 2 - Node protection miss,
            3 - SRLG protection miss, 4 - Merge point not ideal, 255 - Invalid

Bypass trunk: BYPASS2-172.31.222.19
Bypass trunk bandwidth type: best-effort
Total LSP protected : 0
 Bandwidth in use : 0

Bypass trunk: BYPASS3-172.31.222.9
Bypass trunk bandwidth type: best-effort
List of LSP's Protected:
Tunnel-id  Lsp-Id    Lsp-Name                       Role      Ext_tnl_id      Ingress         Egress          Match-Code
61976      3         to_OKL_STRICT                   Transit    172.31.2.52      172.31.2.52      172.31.54.2      0
61975      4         to_OKL_2ND_LOOSE                Transit    172.31.2.52      172.31.2.52      172.31.54.2      0
20         23884      to_OKL_1ST_LOOSE::to_OKL_1ST_LOOSE
                                                     Transit    172.31.33.120    172.31.33.120    172.31.54.2      0
22         5478       to_OKL_2ND_LOOSE::to_OKL_2ND_LOOSE
                                                     Transit    172.31.33.120    172.31.33.120    172.31.54.2      0
61974      3          to_OKL_1ST_LOOSE              Transit    172.31.2.52      172.31.2.52      172.31.54.2      0
21         36172      to_OKL_STRICT::to_OKL_STRICT   Transit    172.31.33.120    172.31.33.120    172.31.54.2      0
Total LSP protected : 6
 Bandwidth in use : 0
```

show rsvp control-adjacency

Use this command to display RSVP specific information for control adjacency.

Command Syntax

```
show rsvp control-adjacency
show rsvp control-adjacency CANAME
```

Parameters

CANAME	Use this parameter to display the name of a control-adjacency

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#"show rsvp control-adjacency" without parameters:
Control Adj    Admin status   Oper Status    Peer-address   Gifindex
Control Channel

#"show rsvp control-adjacency" with parameters:
Admin Status"Enabled" : "Disabled"
Oper Status"Up" : "Down"
Peer-address
Gifindex
Control-Channel in usecc->name : "N/A"
Control-Channel Gifindex
Control-Channel Local-address
Control-Channel Peer-address
Control-Channel ID
Control-Channel Binding Ifindex
Refresh Reduction usage"Disabled" : "Enabled"
Message Acknowledgement"Enabled" : "Disabled"
Bundle Buffer size
Current Epoch Value
Primary IPv4 addressIPv4_address : "N/A"
Primary IPv6 addressIPv6_address : "N/A"
Configured refresh time
Configured keep multiplier
Acknowledgement Await Timeout
Hello Receipt"Enabled" : "Disabled"
Hello Interval
Hello Timeout
Non IANA Hello exchange"Enabled" : "Disabled"
```

Table 7-5 explains the show command output fields.

Table 7-5: show rsvp control-adjacency output field

Field	Description
Control Adj	Control Adjacency status and configuration.
Admin status	Indicates whether the user can administratively disable a peer while still preserving its configuration. Up = Yes, Down = No.
Oper Status	Displays the current status of the cross-connect segment – Up or Down.
Peer-address	Peer address in aa IPv4 and IPv6 format.
Gifindex	Number of gif index on which RSVP is active.
Control Channel	Control Channel status and configuration.
Refresh Reduction usage	Measure of processing over head requests of refresh messages.
Message Acknowledgment	The router that initiates the acknowledgment messages for an RSVP session.
Bundle Buffer size	Number of bundle buffer size.
Current Epoch Value	Value of the database epoch and number of entries in the epoch.
Primary IPv4 address	Primary IPv4 address of the neighbor interface.
Primary IPv6 address	Primary IPv6 address of the neighbor interface.
Configured Refresh Time	Time refresher which takes to generate periodic RSVP messages.
Configured Keep Multiplier	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Acknowledgment Await Timeout	The router that initiates the acknowledgment messages for an RSVP session waits for the timeout.
Hello Receipt	To exchange Hello messages among neighbors.
Hello Interval	Frequency at which RSVP hellos are sent on this interface (in seconds).
Hello Timeout	RSVP Hello State Timer feature detects when a neighbor is down and triggers faster state timeout.
Non IANA Hello exchange	Hello exchange state in the interface.

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show rsvp data-link

Use this command to display RSVP specific information for data links.

Command Syntax

```
show rsvp data-link
show rsvp data-link DLNAME
```

Parameters

DLNAME	Data link name

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#sh rsvp data-link
```

show rsvp graceful-restart

To modify the lines displayed, use the | (output modifier token); to save the output to a file, use the > output redirection token.

Command Syntax

```
show rsvp graceful-restart
show rsvp graceful-restart A.B.C.D
```

Parameters

A.B.C.D	IPv4 address of a specific neighbor (optional).

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 5.0.

Example

```
#show rsvp graceful-restart
Graceful Restart: Enabled
Advertised Restart Time: 180000 msec
Advertised Recovery Time: 360000 msec
Sending Recovery Time: Yes
Remote addr: 172.16.10.2 Local addr: 172.16.10.1
Nbr State: Normal Type: Reroute
Nbr Hello State: Up
LSPs protecting: 0
Restart Time: 0 msec, Recovery Time: 0 msec
Rest of Restart Time: 0 msec, Rest of Recovery Time: 0 msec
```

show rsvp interface

Use this command to display data about RSVP-specific information for interfaces, or about a specific interface.

Command Syntax

```
show rsvp interface
show rsvp interface IFNAME
```

Parameter

IFNAME	The name of the interface to display data.

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp interface eth0
Status                          : Enabled
Interface Index                 : 2
Refresh Reduction usage         : Enabled
Message Acknowledgement         : Disabled
Bundle Buffer size              : 65535
Current Epoch Value             : 208043005
Primary IPv4 address            : 10.10.23.1
Primary IPv6 address            : N/A
Interface Type                  : Ethernet
Administrative Group            : a
                                : d
Configured refresh time         : 5
Configured keep multiplier      : 3
Acknowledgement Await Timeout : 10
Hello Receipt                   : Disabled
Hello Interval                  : 2
Hello Timeout                   : 10
Non IANA Hello exchange         : Disabled
#
```

Table 7-6 explains the show command output fields.

Table 7-6: show rsvp interface output field

Field	Description
Status	Display the status of Resource Reservation Protocol (RSVP).
Interface Index	Number of interface index on which RSVP is active.
Refresh Reduction usage	Measure of processing over head requests of refresh messages.

Table 7-6: show rsvp interface output field

Field	**Description**
Message Acknowledgement	The router that initiates the acknowledgment messages for an RSVP session.
Bundle Buffer size	Number of bundle buffer size.
Current Epoch Value	Value of the database epoch and number of entries in the epoch.
Primary IPv4 address	Primary IPv4 address of the neighbor interface.
Primary IPv6 address	Primary IPv6 address of the neighbor interface.
Interface Type	Type of interface.
Administrative Group	The administrators who belong to the same administrative group.
Configured Refresh Time	Time refresher which takes to generate periodic RSVP messages.
Configured Keep Multiplier	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Acknowledgment Await Timeout	The router that initiates the acknowledgment messages for an RSVP session waits for the timeout.
Hello Receipt	To exchange Hello messages among neighbors.
Hello Interval	Frequency at which RSVP hellos are sent on this interface (in seconds).
Hello Timeout	RSVP Hello State Timer feature detects when a neighbor is down and triggers faster state timeout.
Non IANA Hello exchange	Hello exchange state in the interface.

show rsvp l2-info

Use this command to display MAC and out interface details of a bypass tunnel which is used to send control messages of protected sessions over bypass tunnel when protected session is using backup.

Command Syntax

```
show rsvp l2-info
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp l2-info
============================================================
## Bypass ftn l2 info ##
Ftn IX: 1
Out label: 52521 Out if 100022
src addr:(34ef.b63d.57a9)
Dst addr:(34ef.b694.3e08)
============================================================
============================================================
## Bypass ftn l2 info ##
Ftn IX: 2
Out label: 3 Out if 100022
src addr:(34ef.b63d.57a9)
Dst addr:(34ef.b694.3e08)
============================================================
```

show rsvp local-addresses

Use this command to display data about any configured RSVP local address, including either IPv4 or IPv6 addresses.

Command Syntax

```
show rsvp local-addresses
show rsvp local-addresses ipv4
show rsvp local-addresses ipv6
```

Parameters

ipv4	Use this parameter to display IPv4 local addresses.
ipv6	Use this parameter to display IPv6 local addresses.

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp local-addresses
IPv4 Addresses:
 Address                      Interface
 4.4.4.40                     lo
 10.1.2.40                    eth0
 14.14.14.8                   eth4
 34.0.0.40                    eth2
 80.0.0.40                    eth2
 127.0.0.1                    lo
IPv6 Addresses:
 Address                      Interface
 ::1                          lo
 fe80::202:b3ff:fed5:8dbb     eth4
 fe80::202:b3ff:fed5:9842     eth2
 fe80::20e:cff:fe83:3727      eth0
#
```

Table 7-7 explains the show command output fields.

Table 7-7: show rsvp local-addresses output field

Field	Description
IPv4 Addresses	IPv4 address for the interface.
IPv6 Addresses	IPv6 address for the interface.
Address	Address for the interface.
Interface	Name of the interface.

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show rsvp neighbor

Use this command to display a list of IPv4 RSVP neighbors or just a single IPv4 RSVP neighbor.

Command Syntax

```
show rsvp neighbor
show rsvp neighbor A.B.C.D
```

Parameters

`A.B.C.D`	Use this parameter to display the IP address of the IPv4 RSVP neighbor.

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp neighbor
IP Address          UpStrm LSP DnStrm LSP RefreshReduc Srefresh In  Type
10.10.20.4          0          1          Enabled      5s           Implicit
10.10.23.2          0          1          Enabled      8s           Implicit
#
```

Table 7-8 explains the show command output fields.

Table 7-8: show rsvp neighbor output field

Field	Description
IP Address	Address for the interface.
UpStrm LSP	Specify the upstream label for the bidirectional label-switched path (LSP).
DnStrm LSP	Specify the dnstream label for the bidirectional label-switched path (LSP).
Refresh Reduc	Refresh reduction improves the scalability, latency, and reliability of Resource Reservation Protocol (RSVP) signaling to enhance network performance and message delivery.
Srefresh In	Remaining seconds for srefresh timer expiry.
Type	Type of neighbor interface.

show rsvp nexthop-cache

Use this command to display the current nexthops being cached by RSVP.

Command Syntax

```
show rsvp nexthop-cache
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp nexthop-cache
Prefix              Nexthop          Outgoing Intf  Valid For   Num Sessions
10.10.20.80/32      0.0.0.0          eth1           12 seconds  1
10.10.23.60/32      0.0.0.0          eth0           17 seconds  1
#
```

Table 7-9 explains the show command output fields.

Table 7-9: show rsvp nexthop-cache output field

Field	Description
Prefix	It is an ordered list and entries are evaluated in order of increasing sequence number.
Nexthop	IP address of the next hop.
Outgoing Intf	Short name of the physical interface through which traffic goes to the protected link.
Valid For	Frequency at which RSVP hellos are sent next hop on this interface (in seconds).
Num Sessions	Number of session in the interface.

show rsvp path

Use this command to display the configured rsvp paths and their configured hops. Specify the pathname to show hops related to a specific path. If no pathname is specified all the rsvp paths are displayed.

Command Syntax

```
show rsvp path
show rsvp path PATHNAME
```

Parameter

PATHNAME	The name of a specific path.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following are sample outputs from this command, with and without a PATHNAME (PRI) specified.

```
#show rsvp path
Path name: PRI, id: 1
 10.10.11.51 strict
 10.10.12.50 strict
 10.10.13.51 strict

Path name: SEC, id: 2
 10.10.10.51 strict

Path name: loop, id: 3
 10.10.11.51 strict
 10.10.12.50 strict
 10.10.13.51 strict
 10.10.14.50 strict
#

#show rsvp path PRI
Path name: PRI, id: 1
 10.10.11.51 strict
 10.10.12.50 strict
 10.10.13.51 strict
#
```

Table 7-10 explains the show command output fields.

Table 7-10: show rsvp path output field

Field	Description
Path name	Name of the path.
id	Address of the rsvp path.

show rsvp protected-lsp-reop-list

Use this command to display list of facility protected sessions which didn't get any bypass protection or didn't get a perfect bypass protection. These sessions are checked for better protection whenever a new bypass session comes up.

Command Syntax

```
show rsvp protected-lst-reop-list
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp protected-lsp-reop-list
Tunnel-id  Lsp-Id     Lsp-Name                            Role       Ext_tnl_id       Ingress          Egress           Protected
222       169        LHR_t222                            Transit    172.31.53.18     172.31.53.18     172.31.2.52      Yes
204       1522       LHR_t204                            Transit    172.31.53.18     172.31.53.18     172.31.33.120    Yes
17         52608      GGN_NDLS_2ND_LOOSE::to_CISCO_2ND_LOOSE
                                                            Transit    172.31.33.120    172.31.33.120    172.31.53.18     Yes
```

show rsvp session

Use this command to display session-related information for configured LSPs.

Command Syntax

```
show rsvp session
show rsvp session up
show rsvp session up detail
show rsvp session down
show rsvp session down detail
```

Parameters

up	Use this parameter to display sessions that are currently operational.
down	Use this parameter to display sessions that are currently not operational.
detail	Use this parameter to display detailed session-related information.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following is a sample output from the command using the detail parameter.

```
#show rsvp session detail
Ingress (Primary)
10.10.21.3
  From: 1.1.1.1, LSPstate: Up, LSPname: t1
  Setup priority: 5, Hold priority: 5
  CSPF usage: Disabled
  LSP Protection: None
  Label in: -,  Label out: 16,
  Tspec rate: 10m, Fspec rate: 10m
  Tunnel Id: 1, LSP Id: 2, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.10.23.2, eth0
  Path refresh: 5 seconds (due in 6772 seconds)
  Resv lifetime: 26 seconds (due in 25 seconds)
  Retry count: 0, intrvl: 30 seconds
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups: none
  Configured Path: p1 (in use)
  Configured Explicit Route Detail :
   10.10.23.2/32 strict
  Session Explicit Route Detail :
   10.10.23.2/32 strict
  Record route: <self> 10.10.23.2 10.10.21.3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
```

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```
    Minimum Path MTU: 1500
    LSP Type:  ELSP_SIGNAL
    CLASS    DSCP_value     EXP_value
  #
```

Table 7-11 explains the show command output fields.

Table 7-11: show rsvp session output field

Field	Description
Ingress (Primary)	Information about ingress RSVP sessions. Each session has one line of output.
From	Source (ingress switch) of the session.
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSPname	Name of the LSP.
Setup priority	Value of the setup priority.
Hold priority	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully.
CSPF usage	CSPF usage state in the rsvp session.
LSP Protection	Protects the traffic failures.
Label in	Incoming label for this LSP.
Label out	Outgoing label for this LSP.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Tunnel id	Tunnel address (destination port) for the session.
LSP id	Address of the LSP in the interface.
Ext-Tunnel Id	Session address for the ext-tunnel.
Down stream	Specify the dnstream label for the bidirectional label-switched path (LSP).
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
LSP Type	Type of ELSP signal.

show rsvp session count

Use this command to display session-related information for configured LSPs.

Command Syntax

```
show rsvp session count
show rsvp session count egress
show rsvp session count ingress
show rsvp session count transit
```

Parameters

`egress`	Use this parameter to display the number of configured egress sessions.
`ingress`	Use this parameter to display the number of configured ingress sessions.
`transit`	Use this parameter to display the number of configured transmit sessions.

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp session count
Total configured: 1520, Up 1520, Down 0
#
```

Table 7-12 explains the show command output fields.

Table 7-12: show rsvp session count output field

Field	Description
Total configured	Number of configured rsvp session in the interface.

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show rsvp session egress

Use this command to display session-related information for an egress router.

Command Syntax

```
show rsvp session egress
show rsvp session egress A.B.C.D
show rsvp session egress X:X::X:X
show rsvp session egress detail
show rsvp session egress down
show rsvp session egress down detail
show rsvp session egress up
show rsvp session egress up detail
```

Parameters

A.B.C.D	Use this parameter to display an IPv4 address of an egress router
X:X::X:X	Use this parameter to display an IPv6 address of an egress router
down	Use this parameter to display sessions that are currently not operational
up	Use this parameter to display sessions that are currently operational
detail	Use this parameter to display detailed session-related information

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

```
#show rsvp session egress without parameters or with "up" or "down":
%s RSVP:
To               From             State                Pri Rt  Style Labelin
Labelout LSPName                          Uptime  Est.time   DSType
...
Total %d displayed

#show rsvp session egress with parameters:
"Bypass", "Primary", "Detour", "Secondary"
 Make-Before-Break Sibling for session with LSP-ID:prefix4: prefix6
  From: u.prefix4: u.prefix6
LSPstate: %s, LSPname:
      "Up/"Using Backup"/"Using Secondary"
      "Dn",
  Revert hold timer is ON due to expire in %d seconds
  Revert Timer Finished, Forced Switch to Secondary LSP In Effect
  CSPF usage: "Disabled" : "Enabled"
  , CSPF Retry Count: %d, CSPF Retry Interval: %d seconds"
  IGP-Shortcut: Enabled, LSP metric:
  IGP-Shortcut: Disabled, LSP metric:
```

```
  LSP Protection:
  Bypass trunk:
  Label in:
  Label out:
  Tspec rate:
  Fspec rate:
  Policer: Configured
      and installed in hardware
      but not installed in hardware
      Not Configured
  Tunnel Id: %d, LSP Id: %d
Ext-Tunnel Id:
  Downstream:
  Upstream:
  Path refresh: %d seconds (RR enabled), (due in %d seconds)
  Path lifetime: %d seconds (due in %d seconds)
  Resv refresh: %d seconds (due in %d seconds)
  Resv lifetime: %d seconds (due in %d seconds)
  Retry count: %d, intrvl: %d seconds", # remaining, next retry in: %d
seconds",
  RRO re-use as ERO:  "Enabled" : "Disabled"
  Label Recording: "Enabled" : "Disabled"
  FRR Admin Groups/Admin Groups:
     ***admin group info***
  Exclude path detail:
   Exclude "Link" : "Node
   Configured Path: "none" : "in use" : "not in use"
   %s Explicit Route Detail  "Configured" : "Received"
       "strict" : "loose"
  Record route: " <self>") "  ...incomplete"
  Style: %s\n", rsvp_style_to_str (style));
  Traffic type:  "guaranteed" : "controlled-load" : "none"
  Minimum Path MTU:
  Traffic type: N/A
  Minimum Path MTU: N/A
  LSP Type:  "ELSP_SIGNAL" : "ELSP_CONFIG"
  CLASS    DSCP_value     EXP_value
  The class to exp bits mapping is invalid.
  LSP Type:  L-LSP
  LLSP DSCP: %d%d%d%d%d%d   CLASS: %4s",
  DSTE CLass Type Number: Invalid, Class Type name(configured):
  DSTE Class Type Number: %d, Class Type name:
  Last Recorded Error Code: %s (%d)
  Last Recorded Error Value: %s (%d)
  Node where Last Recorded Error originated:
  Trunk Type: "gmpls" : "mpls"
  Tesid:
Merge Point Adderss [%d] =
```

Table 7-13 explains the show command output fields.

Table 7-13: show rsvp session egress output field

Field	Description
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSP name	Name of the LSP.
CSPF usage	CSPF usage state in the rsvp session.
CSPF Retry Count	Number of times CSPF tried to find the path.
CSPF Retry Interval	The interval at which CSPF retry to find the path.
IGP-Shortcut	Status of IGP shortcut for the RSVP trunk.
LSP metric	Relative/Absolute metric value of the LSP.
LSP Protection	LSP Protection configured for the RSVP trunk.
Bypass trunk	Name for the configured Bypass trunk.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Policer	QoS Policy configured for the RSVP trunk.
Tunnel Id	Tunnel identifier (destination port) for the RSVP session.
LSP Id	Address of the LSP in the interface.
Ext-Tunnel Id	Ext Tunnel identifier (destination port) for the RSVP session.
Down stream	Specify the dn stream label for the bidirectional label-switched path (LSP).
Upstream	Address of the previous hop for the egress session.
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Path lifetime	Number of seconds remaining in the lifetime of the reservation.
Resv refresh	Remaining time in seconds for the next Resv refresh.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
next retry in	Remaining time in seconds for the next retry.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
FRR Admin Groups/Admin Groups	Resource affinities associated with the rsvp session.

Table 7-13: show rsvp session egress output field

Field	Description
Exclude path detail	Detailed List of the link addresses to be excluded for RSVP Bypass session.
Exclude Link	Address of the Link to be excluded for RSVP Bypass session.
Configured Path	Configured path name associated with the rsvp session.
Record route	Established rsvp path with each hop information.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
LSP Type	Type of ELSP signal.
CLASS	Name of the class which is associated with rsvp session.
DSCP_value	DSCP value of diff-serv class which is associated with rsvp session.
EXP_value	EXP value of diff-serv class which is associated with rsvp sess
DSTE Class Type Number	Diff-serv class type number associated with rsvp session.
Class Type name	Diff-serv class type name associated with rsvp session.
Last Recorded Error Code	The last recorded error code for the RSVP session.
Last Recorded Error Value	The last recorded error for the RSVP session.
Node where Last Recorded Error originated	Error originated node in the rsvp session.
Trunk Type	Trunk type in the rsvp session.
Tesid	Traffic Engineering Service Instance Identifier
Merge Point Adderss	Address of the node where the Bypass LSP joins with the protected LSP.

show rsvp session ingress

Use this command to display session-related information for an ingress router.

Command Syntax

```
show rsvp session ingress
show rsvp session ingress A.B.C.D
show rsvp session ingress X:X::X:X
show rsvp session ingress detail
show rsvp session ingress down
show rsvp session ingress down detail
show rsvp session ingress up
show rsvp session ingress up detail
```

Parameters

`A.B.C.D`	Use this parameter to display an IPv4 address of an ingress router
`X:X::X:X`	Use this parameter to display an IPv6 address of an ingress router.
`down`	Use this parameter to display sessions that are currently not operational
`up`	Use this parameter to display sessions that are currently operational
`detail`	Use this parameter to display detailed session-related information

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Examples

`#show rsvp session ingress` (without parameters or with `up` or `down`:)

```
%s RSVP:
To                 From               State                    Pri Rt   Style Labelin
Labelout LSPName                           Uptime  Est.time    DSType
...
Total %d displayed

#show rsvp session ingress detail
Ingress (Primary)
41.41.41.31
From: 29.29.29.29, LSPstate: Up, LSPname: t1-Primary
Ingress FSM state: Operational
Establishment Time: 0s 3ms
Setup priority: 7, Hold priority: 0
CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
IGP-Shortcut: Disabled, LSP metric: 1
LSP Protection: None
Label in: -, Label out: 24320, ELC
```

`#show rsvp session ingress` (with parameters:)

```
"Bypass", "Primary", "Detour", "Secondary"
 Make-Before-Break Sibling for session with LSP-ID:prefix4: prefix6
  From: u.prefix4: u.prefix6
LSPstate: %s, LSPname:
      "Up/"Using Backup"/"Using Secondary"
      "Dn",
  Revert hold timer is ON due to expire in %d seconds
  Revert Timer Finished, Forced Switch to Secondary LSP In Effect
  CSPF usage: "Disabled" : "Enabled"
  CSPF Retry Count: %d, CSPF Retry Interval: %d seconds"
  IGP-Shortcut: Enabled, LSP metric:
  IGP-Shortcut: Disabled, LSP metric:
  LSP Protection:
  Bypass trunk:
  Label in:
  Label out:
  Tspec rate:
  Fspec rate:
  Policer: Configured
      and installed in hardware
      but not installed in hardware
      Not Configured
  Tunnel Id: %d, LSP Id: %d
Ext-Tunnel Id:
  Downstream:
  Upstream:
  Path refresh: %d seconds (RR enabled), (due in %d seconds)
  Path lifetime: %d seconds (due in %d seconds)
  Resv refresh: %d seconds (due in %d seconds)
  Resv lifetime: %d seconds (due in %d seconds)
  Retry count: %d, intrvl: %d seconds", # remaining, next retry in: %d
seconds",
  RRO re-use as ERO:  "Enabled" : "Disabled"
  Label Recording: "Enabled" : "Disabled"
  FRR Admin Groups/Admin Groups:
     ***admin group info***
  Exclude path detail:
   Exclude "Link" : "Node
   Configured Path: "none" : "in use" : "not in use"
   %s Explicit Route Detail  "Configured" : "Received"
       "strict" : "loose"
  Record route: " <self>") "  ...incomplete"
  Style: %s\n", rsvp_style_to_str (style));
  Traffic type:  "guaranteed" : "controlled-load" : "none"
  Minimum Path MTU:
  Traffic type: N/A
  Minimum Path MTU: N/A
  LSP Type:  "ELSP_SIGNAL" : "ELSP_CONFIG"
  CLASS    DSCP_value     EXP_value
  The class to exp bits mapping is invalid.
  LSP Type:  L-LSP
  LLSP DSCP: %d%d%d%d%d%d   CLASS: %4s",
  DSTE CLass Type Number: Invalid, Class Type name(configured):
  DSTE Class Type Number: %d, Class Type name:
  Last Recorded Error Code: %s (%d)
```

```
      Last Recorded Error Value: %s (%d)
      Node where Last Recorded Error originated:
      Trunk Type: "gmpls" : "mpls"
      Tesid:
    Merge Point Adderss [%d] =


    #show mpls forwarding-table
    Codes: > - installed FTN, * - selected FTN, p - stale FTN, B - BGP FTN, K -
    CLI FTN, t - tunnel
    L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,
    U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

    Code    FEC          FTN-ID Tunnel-id  Pri  LSP-Type   Out- Label  ELC  Out-
    Intf  Nexthop
    R(t)> 2 9.29.29.29/32  1    5001       Yes LSP_DEFAULT   24322    yes
    eth2    1.41.41.31
    R(t)>   29.29.29.29/32  2   5001        No  LSP_DEFAULT   4322    yes
    eth1    69.69.69.42
```

Table 7-14 explains the show command output fields.

Table 7-14: show rsvp session ingress output field

Field	Description
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSP name	Name of the LSP.
CSPF usage	CSPF usage state in the rsvp session.
CSPF Retry Count	Number of times CSPF tried to find the path.
CSPF Retry Interval	The interval at which CSPF retry to find the path.
IGP-Shortcut	Status of IGP shortcut for the RSVP trunk.
LSP metric	Relative/Absolute metric value of the LSP.
LSP Protection	LSP Protection configured for the RSVP trunk.
Bypass trunk	Name for the configured Bypass trunk.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Policer	QoS Policy configured for the RSVP trunk.
Tunnel Id	Tunnel identifier (destination port) for the RSVP session.
LSP Id	Address of the LSP in the interface.
Ext-Tunnel Id	Ext Tunnel identifier (destination port) for the RSVP session.
Down stream	Specify the dn stream label for the bidirectional label-switched path (LSP).

Table 7-14: show rsvp session ingress output field

Field	Description
Upstream	Address of the previous hop for the egress session.
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Path lifetime	Number of seconds remaining in the lifetime of the reservation.
Resv refresh	Remaining time in seconds for the next Resv refresh.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
next retry in	Remaining time in seconds for the next retry.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
FRR Admin Groups/Admin Groups	Resource affinities associated with the rsvp session.
Exclude path detail	Detailed List of the link addresses to be excluded for RSVP Bypass session.
Exclude Link	Address of the Link to be excluded for RSVP Bypass session.
Configured Path	Configured path name associated with the rsvp session.
Record route	Established rsvp path with each hop information.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
LSP Type	Type of ELSP signal.
CLASS	Name of the class which is associated with rsvp session.
DSCP_value	DSCP value of diff-serv class which is associated with rsvp session.
EXP_value	EXP value of diff-serv class which is associated with rsvp sess
DSTE Class Type Number	Diff-serv class type number associated with rsvp session.
Class Type name	Diff-serv class type name associated with rsvp session.
Last Recorded Error Code	The last recorded error code for the RSVP session.
Last Recorded Error Value	The last recorded error for the RSVP session.
Node where Last Recorded Error originated	Error originated node in the rsvp session.

Table 7-14: show rsvp session ingress output field

Field	Description
Trunk Type	Trunk type in the rsvp session.
Tesid	Traffic Engineering Service Instance Identifier.
Merge Point Adderss	Address of the node where the Bypass LSP joins with the protected LSP.

show rsvp session LSP-NAME

Use this command to display information only for sessions with a specified name.

Note: This command doesn't work for sessions with tunnel name larger than 32 characters or sessions originated from non-OcNOS solutions.

Command Syntax

```
show rsvp session LSP-NAME
show rsvp session LSP-NAME primary
show rsvp session LSP-NAME secondary
```

Parameters

`primary`	Use this parameter to display any primary LSP sessions
`secondary`	Use this parameter to display any secondary LSP sessions

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Usage

Following is a sample output from the command displaying session information about the LSP named `t1`.

```
#show rsvp session t1
Ingress (Primary)
192.168.0.90
  From: 192.168.0.63, LSPstate: Up, LSPname: t1
  Setup priority: 7, Hold priority: 0
  CSPF usage: Disabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  Label in: -,  Label out: 17,
  Tspec rate: 0
  Tunnel Id: 1, LSP Id: 1, Ext-Tunnel Id: 192.168.0.63
  Downstream: 10.10.23.60, eth0
  Path refresh: 30 seconds (due in 34 seconds)
  Resv lifetime 157 seconds (due in 155 seconds)
  Retry Count: 0, Retry Interval: 30 seconds
  RRO re-use as ERO: Enabled
  Labels Recording: Disabled
  Admin Groups: include-any -->  0(a)
  Configured Path: p1 (in use)
  Configured Explicit Route Detail :
   10.10.23.60/32 loose
  Session Explicit Route Detail :
   10.10.23.60/32 loose
   10.10.21.90/32 loose
  Record route: <self> 10.10.23.60 10.10.21.90
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  Last Recorded Error Code: None
```

```
    Last Recorded Error Value: None
#
```

Table 7-15 explains the show command output fields.

Table 7-15: show rsvp session LSP-NAME output field

Field	Description
Ingress (Primary)	Information about ingress RSVP sessions. Each session has one line of output.
From	Source (ingress switch) of the session.
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSPname	Name of the LSP.
Setup priority	Value of the setup priority.
Hold priority	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully.
CSPF usage	CSPF usage state in the rsvp session.
LSP Protection	Protects the traffic failures.
Label in	Incoming label for this LSP.
Label out	Outgoing label for this LSP.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Tunnel id	Tunnel address (destination port) for the session.
LSP id	Address of the LSP in the interface.
Ext-Tunnel Id	Session address for the ext-tunnel.
Down stream	Specify the dnstream label for the bidirectional label-switched path (LSP).
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
Retry count	Number of times sanity polling periodically checks for an error condition in the FPC.
intrvl	Interval sets the time for the messages in order to control the session.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
Admin Groups	Resource affinities associated with the rsvp session.

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Table 7-15: show rsvp session LSP-NAME output field

Field	Description
Configured Path	Configured path name associated with the rsvp session.
Configured Explicit Route Detail	Configured explicit route with each hop information.
Session Explicit Route Detail	Established explicit route with each hop information.
Record route	Established rsvp path with each hop information.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
Last Recorded Error Code	Recorded error code for the last time service ran.
Last Recorded Error Value	No Recorded error value for the last time service ran.

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show rsvp session transit

Use this command to display session-related information for the transit or intermediate router.

Command Syntax

```
show rsvp session transit
show rsvp session transit detail
show rsvp session transit up
show rsvp session transit down
show rsvp session transit up detail
show rsvp session transit down detail
```

Parameters

`up`	Use this parameter to display sessions that are operational
`down`	Use this parameter to display sessions that are not operational
`detail`	Use this parameter to display detailed session-related information

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

Following are sample outputs from the command displaying detailed session information for the transit router.

```
#show rsvp session transit detail
Transit (Primary)
10.10.21.3
  From: 1.1.1.1, LSPstate: Up, LSPname: t1
  Setup priority: 5, Hold priority: 5
  LSP Protection: None
  Label in: 16,  Label out: 3,
  Tspec rate: 10m, Fspec rate: 10m
  Tunnel Id: 1, LSP Id: 2, Ext-Tunnel Id: 1.1.1.1
  Downstream: 10.10.21.3, eth1   Upstream: 10.10.23.1, eth3
  Path refresh: 5 seconds (due in 6155 seconds)
  Path lifetime: 26 seconds (due in 25 seconds)
  Resv refresh: 5 seconds (due in 2533 seconds)
  Resv lifetime: 26 seconds (due in 25 seconds)
  RRO re-use as ERO: Disabled
  Label Recording: Disabled
  Admin Groups:   Received Explicit Route Detail :
   10.10.23.2/32 strict
  Record route: 10.10.23.1 <self> 10.10.21.3
  Style: Shared Explicit Filter
  Traffic type: controlled-load
  Minimum Path MTU: 1500
  LSP Type:  ELSP_SIGNAL
  CLASS    DSCP_value     EXP_value
```

```
    af43      100110          7
    DSTE Class Type Number: 0, Class Type name: default
  #
```

Table 7-16 explains the show command output fields.

Table 7-16: show rsvp session transit output field

Field	Description
Transit (Primary)	Transit RSVP sessions information in the interface.
From	Source (ingress switch) of the session.
LSP state	State of the LSP that is being handled by this RSVP session. It can be either Up, Dn (down), or Admin Dn. Admin Dn indicates that the LSP is being taken down gracefully.
LSP name	Name of the LSP.
Setup priority	Value of the setup priority.
Hold priority	Determines the degree to which an LSP holds onto its session reservation after the LSP has been set up successfully.
LSP Protection	Protects the traffic failures.
Label in	Incoming label for this LSP.
Label out	Outgoing label for this LSP.
Tspec rate	Sender's traffic specification, which describes the sender's traffic parameters.
Fspec rate	Fspec peak rate values.
Tunnel id	Tunnel address (destination port) for the session.
LSP id	Address of the LSP in the interface.
Ext-Tunnel Id	Session address for the ext-tunnel.
Down stream	Specify the dnstream label for the bidirectional label-switched path (LSP).
Path refresh	Path messages are sent periodically to refresh path states. The refresh interval is controlled by a variable called the refresh time.
Resv lifetime	Number of seconds remaining in the lifetime of the reservation.
RRO re-use as ERO	Enabling to re-use Record route as Explicit route for rsvp session.
Label Recording	Enabling to record the labels exchanged by all the peers.
Admin Groups	Resource affinities associated with the rsvp session.
Configured Explicit Route Detail	Configured path name associated with the rsvp session.

Table 7-16: show rsvp session transit output field

Field	Description
Record route	Recorded route for the session, taken from the record route object. Normally this value will be the same as that of explct route. Differences indicate that path rerouting has occurred, typically during fast reroute.
Style	Reservation style associated with the rsvp session.
Traffic type	Traffic type associated with the rsvp session.
Minimum Path MTU	Path maximum transmission unit (MTU) discovery in the interface.
LSP Type	Type of LSP for Diffserv services(E-LSP or L-LSP).
CLASS	Name of the class which is associated with rsvp session.
DSCP_value	DSCP value of diff-serv class which is associated with rsvp session.
EXP_value	EXP value of diff-serv class which is associated with rsvp session.
DSTE Class Type Number	Diff-serv class type number associated with rsvp session.
Class Type name	Diff-serv class type name associated with rsvp session.

show rsvp statistics

Use this command to display overall statistics of different type of RSVP control messages sent and received in a node.

Command Syntax

```
show rsvp statistics
```

Parameters

None

Command Mode

```
Exec and Privileged Exec modes
```

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp statistics
  PacketType              Total
                 Sent       Received
  Path            627          501
  PathErr           0           24
  PathTear          1           27
  Resv FF          30            9
  Resv WF           0            0
  Resv SE         646          583
  Resv Err          0            0
  ResvTear          0            0
  ResvConf          0            0
  Hello        330604       334461
  Bundle         1006          866
  Ack              50           14
  SRefresh      34348        32424
  Notify            0            0
```

show rsvp summary-refresh

Use this command to display RSVP summary refresh data.

Command Syntax

```
show rsvp summary-refresh
```

Parameters

None

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp summary-refresh:
Neighbor Addr       Tunnel ID  LSP ID     Ingress              Egress
```

Table 7-17 explains the show command output fields.

Table 7-17: show rsvp trunk output field

Field	Description
Neighbor Addr	Neighbor address on the primary address of the interface.
Tunnel ID	Tunnel identifier (destination port) for the RSVP session.
LSP ID	Address of the LSP in the interface.
Ingress	Information about ingress RSVP sessions.
Egress	Information about egress RSVP sessions.

show rsvp trunk

Use this command to display information for a specific trunk or for all trunks.

Command Syntax

```
show rsvp trunk
show rsvp trunk NAME
show rsvp trunk detail
```

Parameters

NAME	Enter the name of a trunk
detail	Use this parameter to display detailed information for all trunks

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp trunk
Trunk Name       Trunk ID  Type        # Sess        Egress Address(es)
T1               101       P2P              1        4.4.4.4
T2               102       P2P              2        5.5.5.5
Total trunks configured: 3.
#
```

Following is a sample output from the command using the detail parameter.

```
#show rsvp trunk detail
Trunk name: T1, tunnel-id: 101
 Type: P2P
 Ext-tunnel-id: 1.1.1.1/32
 Egress: 4.4.4.4/32
 # of LSPs in trunk: 1
 Mapped-routes: none

Trunk name: T2, tunnel-id: 102
 Type: P2P
 Ext-tunnel-id: 1.1.1.1/32
 Egress: 5.5.5.5/32
 # of LSPs in trunk: 2
 Mapped-routes: none
```

Table 7-18 explains the show command output fields.

Table 7-18: show rsvp trunk output field

Field	Description
Trunk Name	Name of the trunk.
Trunk ID	Session address for the trunk.
Type	Trunk type in the rsvp session.
Sess	Number of sessions associated with rsvp trunk.
Egress	Information about egress RSVP sessions.
Total trunks configured	Number of configured trunk in the rsvp session.
Ext-tunnel-id	Extended Tunnel identifier (destination port) for the RSVP session.
Mapped-routes	Map the route of the interface.

show rsvp trunk multi-sec-detail

Use this command to display secondary priority details specific to a trunk or for all trunks

Command Syntax

```
show rsvp trunk multi-sec-detail
show rsvp trunk NAME multi-sec-detail
```

Parameters

NAME	Enter the name of a trunk

Command Mode

Exec mode and Privileged Exec mode

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
# show rsvp trunk multi-sec-detail
Ingress (Secondary-Priority1)
5.5.5.5
  From: 6.6.6.6, LSPstate: Dn, LSPname: t2-Secondary-Priority-1
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2206, Ext-Tunnel Id: 6.6.6.6
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
Ingress (Secondary-Priority3)
5.5.5.5
  From: 6.6.6.6, LSPstate: Dn, LSPname: t2-Secondary-Priority-3
  Ingress FSM state: Idle
  Setup priority: 7, Hold priority: 0
  CSPF usage: Enabled, CSPF Retry Count: 0, CSPF Retry Interval: 30 seconds
  LSP Re-Optimization: Disabled, Re-Optimization Timer: NA
  IGP-Shortcut: Disabled, LSP metric: 65
  LSP Protection: None
  Label in: -,  Label out: -,
  Tspec rate: 0, Fspec rate: 0
  Policer: Not Configured
  Tunnel Id: 5001, LSP Id: 2206, Ext-Tunnel Id: 6.6.6.6
  Last Recorded Error Code: Routing Problem (24)
  Last Recorded Error Value: No route available toward destination (5)
  Node where Last Recorded Error originated: None
  Trunk Type: mpls
```

show rsvp version

Use this command to display the version of the RSVP daemon. Current RSVP version is 1.

Command Syntax

```
show rsvp version
```

Parameters

None

Command Mode

Exec and Privileged Exec modes

Applicability

This command was introduced before OcNOS version 1.3.

Example

```
#show rsvp version
Resource ReSerVation Protocol, version 1. rfc2205
   RSVP protocol       = Enabled
   R(refresh timer)    = 30 seconds
   K(keep multiplier) = 3
   Preemption          = Normal
#
```

Table 7-19 explains the show command output fields.

Table 7-19: show rsvp version output field

Field	Description
Resource Reservation Protocol	RSVP software version.
RSVP protocol	Status of RSVP.
R (refresh timer)	Configured time interval used to generate periodic RSVP messages.
K (keep multiplier)	Number of RSVP messages that can be lost before an RSVP state is declared stale.
Preemption	Currently configured preemption capability.

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