



OcNOS®

**Open Compute Network Operating System
for Service Providers**

Segment Routing

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PREFACE

About this Guide

This guide describes how to configure Segment Routing in OcNOS.


Audience

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

Conventions

The [Table 1](#) table 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

IP Infusion Product Release Version

Each integer in release numbers indicates Major, Minor, and Maintenance release versions. Build numbers that follow the release numbers are for internal tracking and verification of the software build process and are visible to customers as part of the software version number.



Product Name: IP Infusion Product Family

Major Version: New customer-facing functionality that represents a significant change to the code base; including a significant marketing change or direction in the product.

Minor Version: Enhancements or extensions to existing features, changes to address external needs, or internal improvements to satisfy new sales regions or marketing initiatives.

Maintenance Version: A collection of product bugs or issues usually scheduled every 30 or 60 days, based on the number of issues.

Related Documentation

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

Feature Availability

Each OcNOS SKU contains a set of supported features. For a list of available features based on the SKU that you purchased, refer to the [Feature Matrix](#).

Migration Guide

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

IP Maestro Support

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

Technical Support

IP Infusion maintains an online technical support site that provides a variety of technical support programs for licensed OcNOS customers at the [Technical Assistance Center](#).

Customers and partners enjoy full access to the support website. The site allows customers and partners to open technical support calls, update open calls with new information, and review the status of open or closed calls. The password-protected site includes technical documentation, Release Notes, and descriptions of service offerings.

Technical Sales

Contact the IP Infusion sales representative for more information about the OcNOS solution.

Technical Documentation

For core commands and configuration procedures, visit: [Product Documentation](#).

For training videos, visit: [OcNOS Free Training Videos](#).

For a list of supported platforms and SKUs of OcNOS features, refer to the [OcNOS Feature Matrix](#).

Documentation Disclaimer

The global documentation site is evolving to provide an enhanced website user experience for select topics included in this release. Some guides are now available outside the existing documentation library and can be accessed directly from custom documentation landing pages. These guides offer robust in-built search functionality.

For the latest documentation, visit the product-specific documentation landing page and select the relevant guide.

Comments

If you have comments, or need to report a problem with the content, contact techpubs@ipinfusion.com.

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.

Chapter Organization

The chapters in command references are organized as described in [Command Description Format \(page 49\)](#).

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
-

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 authentication-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](#) 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 (page 48)	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	(A.B.C.D <0-4294967295>)

Table 2. Syntax conventions (continued)

Convention	Description	Example
	selections. Do not enter the parentheses or vertical bars as part of the command.	
()	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>}
[]	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](#) 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

Table 3. Variable placeholders (continued)

Token	Description
XX:XX:XX:XX:XX:XX	MAC address
<1-5> <1-65535> <0-2147483647> <0-4294967295>	Numeric range

Command Description Format

The [Table 4](#) table 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 (page 52)
Applicability	The command introduced in a specific release version and modified or updated in subsequent versions.
Example	An example of the command being executed

Keyboard Operations

The [Table 5](#) table 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

Table 5. Keyboard operations (continued)

Key combination	Operation
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
Ctrl+t	Transposes the current character with the previous character
Ctrl+c	Ignores the current line and redisplay 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
```

String Parameters

The restrictions in [Table 6](#) 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. The table below lists the command modes common to all protocols.

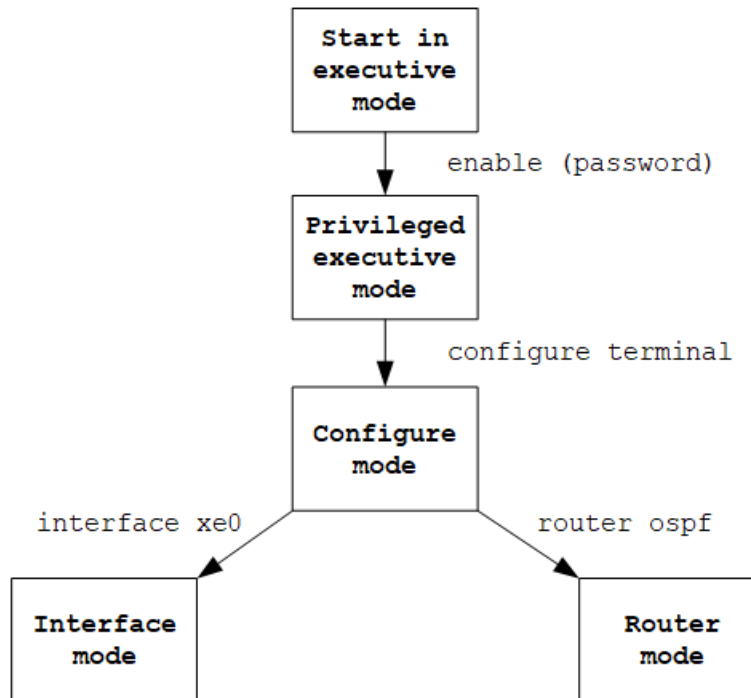
Table 7. Common Command Modes

Name	Description
Execution mode	Also called <i>view</i> 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 execution mode	Also called <i>enable</i> mode, in this mode you can run additional basic commands such as debug, write, and show.
Configure mode	<p>Also called <i>configure terminal</i> 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.</p> <p>Configure mode is single user. Only one user at a time can be in configure mode.</p>
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.

Command Mode Tree

The diagram below shows the common command mode hierarchy.

Figure 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 `.` You must remove each configuration followed by a `commit`.



Note: All commands MUST be executed only in the default CML shell (`cm1sh`). 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.

SEGMENT ROUTING CONFIGURATION

Overview

Source routing is a technique where the sender of a packet can partially or completely specify a route in a network through which a packet is sent. Segment routing is a form of source routing where nodes and links are represented as segments. The path that a particular packet needs to traverse is represented by one or more segments. The list of segments is inserted into the packet itself and each segment in the path represents a particular node or an adjacency through which the packet needs to pass. The OcNOS implementation of segment routing is based on draft-ietf-spring-segment-routing-09.

- A segment can be any instruction, topological or service based.
- A segment can be
 - Local to an SR node or global within an SR domain.
 - IGP-based forwarding construct
 - BGP-based forwarding construct
- A segment may be associated with topological instructions.
- For example:
 - A topological local segment may instruct the node to forward the packet via specific outgoing interface.
 - A topological global segment may instruct the SR domain to forward the packet via specific path to destination.
- A segment may be associated with a service instruction.
- Packet should be processed by a container or Virtual Machine (VM) associated with the segment.
- They are importantly two kinds of segments.

Two Segments

Prefix Segment

It is used to forward the packet along the shortest path to reach the prefix. When the prefix is that of the loopback interface which identifies the node and it's called a Node Segment. Prefix Segments are global segments and all the nodes in SR domain has the forwarding entry available for the prefix segment advertised.

Adjacency Segment

It is used to forward the packet via a specific link to a particular neighbor. It's generally a local segment and only the node which holds the adjacency has the forwarding entry available for that adjacency.

OcNOS uses prefix segments which forward a packet along the shortest path to reach the prefix. Prefix segments are global and all the nodes in the segment routing domain advertise the forwarding entry for the prefix segment. When a prefix is for a loopback interface that identifies a node, it is called a node segment.

Segment routing does not require any additional control plane protocol and is implemented by extending an existing interior gateway protocol (IGP) such as OSPF and ISIS. Segment routing replaces MPLS control plane protocols such as LDP or RSVP.

In OcNOS, MPLS clients such as LDP and RSVP create FEC-to-NHLFE and Incoming Label Map (FTN/ILM) entries by signaling within the MPLS domain. After this, the entries are installed into the MPLS RIB hosted by NSM.

The segment routing framework reuses the existing MPLS framework with OSPF and ISIS which acts as an MPLS client. OSPF and ISIS with segment routing extensions exchanges the segment information within the segment routing domain. These segments are converted to MPLS FTN/ILM entries using a library. After this, the entries are installed into the same MPLS RIB hosted by NSM.

OcNOS supports ISIS and OSPF extensions to achieve segment routing via the MPLS data plane. OcNOS supports prefix segments and adjacency segments.

In segment routing, the path states are maintained only at the ingress node and the path to follow is pushed into the packet itself. The transit and egress nodes do not maintain state for each path traversing through them. The configuration overhead is less than traditional MPLS.

The major benefits of segment routing are as follows.

1. Simplified

- When applied to the MPLS data plane, Segment Routing offers the ability to tunnel MPLS services (VPN, VPLS, and VPWS) from an ingress provider edge to an egress provider edge without any other protocol than an IGP (ISIS or OSPF).
- Simpler operation without separate protocols for label distribution (for example, no LDP or RSVP)
- No complex LDP or IGP synchronization to troubleshoot.

2. Ready for SDN

- Segment Routing is a compelling architecture that supports Software-Defined Network (SDN) and is the foundation for Application Engineered Routing (AER).
- It strikes a balance between network-based distributed intelligence, such as automatic link and node protection, and controller-based centralized intelligence, such as traffic optimization

3. Scalable

- Avoid thousands of labels in LDP database.
- Avoid thousands of MPLS Traffic Engineering LSPs in the network.

- Avoid thousands of tunnels to configure.

4. Supports Fast Reroute (FRR)

- The traditional LFA and RLFA technologies have topology constraints that mean they are unable to implement 100% fault protection
- Segment routing provides Topology Independent Loop Free Alternate (TI-LFA) as its main solution for FRR.
- In case of link or node failures in a network, MPLS uses the FRR mechanism for convergence.

Segment Routing Global Block

The Segment Routing Global Block (SRGB) is a local property of a segment routing node. In the context of MPLS, it is a set of “local labels” for global segments.

By default, OcNOS uses the same local label range (16000-23999) for all the segment routing nodes for SRGB.

If a node participates in multiple SR domains, there is one SRGB for each SR domain. In SR-MPLS, SRGB is a local property of a node and identifies the set of local labels reserved for global segments.

In SR-MPLS, using identical SRGBs on all nodes within the SR domain is strongly recommended. Doing so eases operations and troubleshooting as the same label represents the same global segment at each node.

When SRGB is not configured, the system reserves a default label range.

The SRGB default value is 16000 to 23999. The SRGB can be configured as follows:



Notes: Make sure that the labels in the SRGB label range are not used by any other protocols (LDP, RSVP, BGP, static LSP, ISIS-SR policy, OSPF-SR policy). To check the label ranges configured for each of the protocols use `show mpls label-space 0` and re-configure the SRGB label range with a label range that is available.

SRGB in global mode

```
#conf t
(config)#segment-routing
(config-sr)#global block 30000 50000
```

SRGB declared in global mode can be used by either ISIS or OSPF if they do not have configured SRGB in their respective routing process level.

SRGB under ISIS

```
(config)#router isis isis1
(config-router)#isis segment-routing global block <16-1048575>
```

SRGB under OSPF

```
(config)#router ospf 1
(config-router)#ospf segment-routing global block <16-1048575>
```

Segment Identifiers

Segments are identified by a Segment Identifier (SID) which is an unsigned 32-bit integer. Because the MPLS data plane is used, the segments are identified by a 20-bit integer, leaving the 12 left-most bits of the SID unused. A SID

has an absolute value and index (label) allocated for the segment. Because the SRGB is the same across the entire domain, all nodes identify the segment with the same absolute value.

Prefix SID Absolute Value

Specify an absolute SID-value for each node to create a specific prefix SID within the configured SRGB range.

When a Prefix-SID is configured as absolute, the same value is used for packet-switching.

```
(config-if)#prefix-sid absolute <16-1048575>
```

Prefix SID Index Value

Specify an index SID-index for each node to create a prefix SID based on the lower boundary of the SRGB and the index.

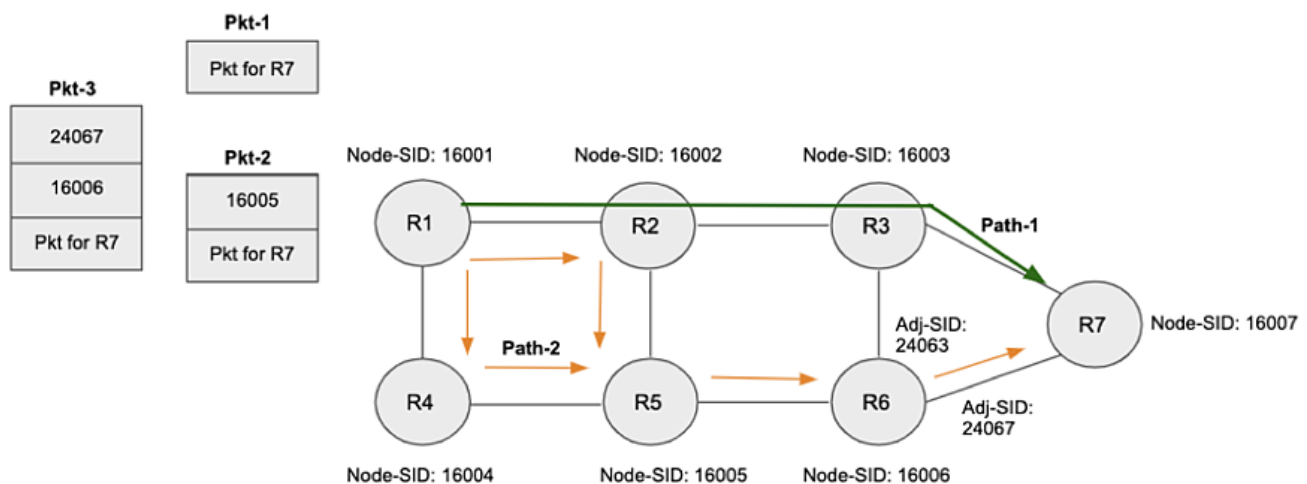
```
(config-if)#prefix-sid index <0-1048575>
```

This index value will be used for calculating absolute MPLS label by adding base value of SRGB. In case of default SRGB (16000-23999) if index value is 1000, the MPLS label value will $(16000 + 1000) = 17000$.

Forwarding Example with SIDs

Figure shows an example of forwarding a packet using a prefix SID.

Figure 2. Forwarding Example



Forwarding example

1. If ingress node R1 receives packet destined for R7 with no SR label stack in packet header, the packet will get forwarded to R7 along the IGP shortest-path (R1-R2-R3-R7).
2. If the packet was received with SR label stack of [16005], R1 inspects the top label which is 16005. 16005 is the node SID associated with R5 and so this tells R1 to forward the packet along IGP shortest-path to R5 (R1-R2-R5 or R1-R4-R5). The next hop node (R2 or R4) does the same action as R1. On receiving the packet, R5

inspects the top label which is 16005 and since it matches its node SID, it pops the top label. There are no more labels in the stack and R5 forwards the packet to R7 along the IGP shortest-path (R5-R6-R7).

3. If the packet was received with SR label stack of [16006, 24067], R1 inspects the top label which is 16006 and because that is the node SID associated with R6, R1 forwards the packet along the IGP shortest-path to R6 (R1-R2-R3-R6, R1-R2-R5-R6 or R1-R4-R5-R6). R6 inspects the top label which is 16006 and because it matches its node SID, R6 pops the top label and inspects the next label which is 24067. 24067 is the adjacency SID associated with R6's adjacency with R7 so this tells R6 to pop the label and forward the packet over its link connected to R7.

Configuring ISIS Segment Routing

This section shows how to configure segment routing using ISIS. ISIS uses ISIS-TE TLVs to advertise any additional attributes associated with prefix by adding new TLVs or sub-TLVs to the existing ISIS-TE TLVs.

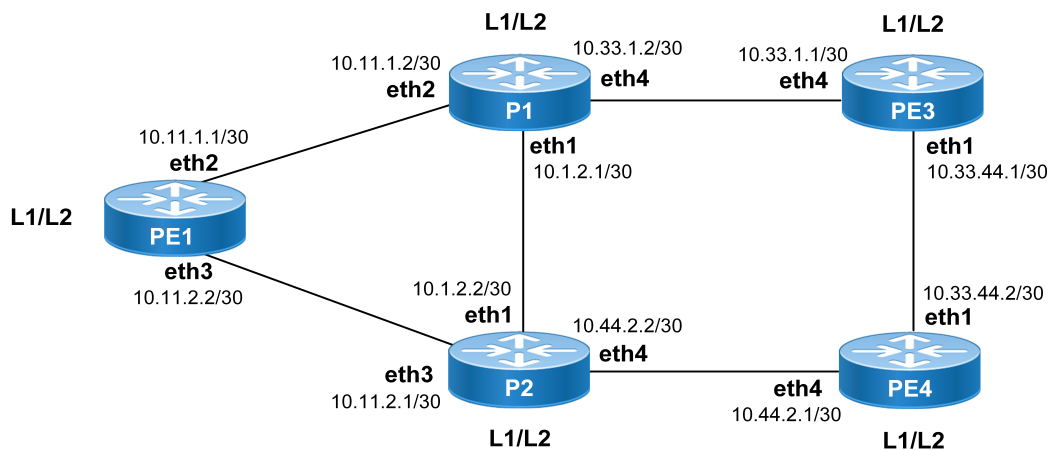
These segments are converted to MPLS labels and installed in the FTN/ILM and forwarding tables.

Topology

- “L1” means ISIS routers in Level-1
- “L2” means ISIS routers in Level-2
- “L1/L2” means ISIS routers in both Level-1 and Level-2

You can configure a prefix SID on any router directly attached to that network prefix.

Figure 3. ISIS Segment Routing Topology



Notes:

- Users must ensure that the prefix SIDs are globally unique.
- Pure L1 or L2 routers can be used throughout the SR domain.

Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 10.0.1.11/32 secondary	Configure the IP address of the interface.

PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#prefix-sid index 100	Configure prefix sid index value.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#commit	Commit candidate configuration to the running configuration
PE1(config)#interface eth2	Enter interface mode.
PE1(config-if)#ip address 10.11.1.1/30	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#commit	Commit candidate configuration to the running configuration
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth3	Enter interface mode.
PE1(config-if)#ip address 10.11.2.2/30	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#commit	Commit candidate configuration to the running configuration
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router isis isis1	Set the routing process ID .
PE1(config-router)#metric-style wide	Configure metric style as wide.
PE1(config-router)#is-type level-1-2	Configure is-type with level-1-2.
PE1(config-router)#net 49.0000.0100.0000.1011.00	Configure Network entity title (NET).
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE1(config-router)# dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
PE1(config-router)# isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
PE1(config-router)#segment-routing mpls	Enable segment routing under router process.
PE1(config-router)#commit	Commit candidate configuration to the running configuration
PE1(config-router)#exit	Exit router mode.

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 10.0.1.1/32 secondary	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#prefix-sid index 200	Configure prefix sid index value.
P1(config-if)#commit	Commit candidate configuration to the running configuration
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth2	Enter interface mode.
P1(config-if)#ip address 10.11.1.2/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#commit	Commit candidate configuration to the running configuration
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth1	Enter interface mode.
P1(config-if)#ip address 10.1.2.1/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#commit	Commit candidate configuration to the running configuration
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth4	Enter interface mode.
P1(config-if)#ip address 10.33.1.2/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#router isis isis1	Set the routing process ID .
P1(config-router)#metric-style wide	Configure metric style as wide.
P1(config-router)#is-type level-1-2	Configure is-type with level-1-2.
P1(config-router)#net 49.0000.0100.0000.1001.00	Configure Network entity title (NET).
P1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P1(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
P1(config-router)# isis segment- routing global block 17000 23500	Enable SRGB under ISIS isis1 process.

P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)#commit	Commit candidate configuration to the running configuration
P1(config-router)#exit	Exit router mode.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 10.0.1.2/32 secondary	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)#prefix-sid index 300 no-php	Configure prefix sid index value with no php.
P2(config-if)#commit	Commit candidate configuration to the running configuration
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth3	Enter interface mode.
P2(config-if)#ip address 10.11.2.1/30	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth1	Enter interface mode.
P2(config-if)#ip address 10.1.2.2/30	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#commit	Commit candidate configuration to the running configuration.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth4	Enter interface mode.
P2(config-if)#ip address 10.44.2.2/30	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#commit	Commit candidate configuration to the running configuration
P2(config-if)#exit	Exit interface mode.
P2(config)#router isis isis1	Set the routing process ID .

P2(config-router)#metric-style wide	Configure metric style as wide.
P2(config-router)#is-type level-1-2	Configure is-type with level-1-2.
P2(config-router)#net 49.0000.0100.0000.1002.00	Configure Network entity title (NET).
P2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2 as well.
P2 (config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
P2(config-router)#isis segment-routing global block 16500 22500	Enable SRGB under ISIS isis1 process.
P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)#commit	Commit candidate configuration to the running configuration
P2(config-router)#exit	Exit router mode.

PE3

The following are the step-by-step configurations on the PE3 router.

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter interface mode.
PE3(config-if)#ip address 10.0.1.33/32 secondary	Configure the IP address of the interface.
PE3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE3(config-if)#prefix-sid index 500	Configure prefix sid index value.
PE3(config-if)#commit	Commit candidate configuration to the running configuration
PE3(config-if)#exit	Exit interface mode.
PE3(config)#interface eth1	Enter interface mode.
PE3(config-if)#ip address 10.33.44.1/30	Configure the IP address of the interface.
PE3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE3(config-if)#label-switching	Enable label switching.
PE3(config-if)#commit	Commit candidate configuration to the running configuration
PE3(config-if)#exit	Exit interface mode.
PE3(config)#interface eth4	Enter interface mode.
PE3(config-if)#ip address 10.33.1.1/30	Configure the IP address of the interface.
PE3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE3(config-if)#label-switching	Enable label switching.
PE3(config-if)#commit	Commit candidate configuration to the running

	configuration
PE3(config-if)#exit	Exit interface mode.
PE3(config)#router isis isis1	Set the routing process ID .
PE3(config-router)#metric-style wide	Configure metric style as wide.
PE3(config-router)#is-type level-1-2	Configure is-type with level-1-2.
PE3(config-router)#net 49.0000.0100.0000.1033.00	Configure Network entity title (NET).
PE3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE3(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level- 2 as well.
PE3(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process
PE3(config-router)# isis segment- routing global block 17500 22000	Enable SRGB under ISIS isis1 process.
PE3(config-router)#segment-routing mpls	Enable segment routing under router process.
PE3(config-router)#commit	Commit candidate configuration to the running configuration
PE3(config-router)#exit	Exit router mode.

PE4

The following are the step-by-step configurations on the PE4 router.

PE4#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter interface mode.
PE4(config-if)#ip address 10.0.1.44/32 secondary	Configure the IP address of the interface.
PE4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE4(config-if)#prefix-sid index 600 no-php	Configure prefix sid index value with no php.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#commit	Commit candidate configuration to the running configuration
PE4(config)#interface eth4	Enter interface mode.
PE4(config-if)#ip address 10.44.2.1/30	Configure the IP address of the interface.
PE4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE4(config-if)#label-switching	Enable label switching.
PE4(config-if)#commit	Commit candidate configuration to the running configuration
PE4(config-if)#exit	Exit interface mode.
PE4(config)#interface eth1	Enter interface mode.
PE4(config-if)#ip address 10.33.44.2/30	Configure the IP address of the interface.

PE4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE4(config-if)#label-switching	Enable label switching.
PE4(config-if)#commit	Commit candidate configuration to the running configuration
PE4(config-if)#exit	Exit interface mode.
PE4(config)#router isis isis1	Set the routing process ID .
PE4(config-router)#metric-style wide	Configure metric style as wide.
PE4(config-router)#net 49.0000.0100.0000.1044.00	Configure Network entity title (NET).
PE4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE4(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE4(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
PE4(config-router)# isis segment- routing global block 18000 23999	Enable SRGB under ISIS isis1 process.
PE4(config-router)#segment-routing mpls	Enable segment routing under router process.
PE4(config-if)#commit	Commit candidate configuration to the running configuration
PE4(config-router)#exit	Exit router mode.



Note: By default, PHP is enabled, to see all the labels in MPLS forwarding and ILM table we have enabled with non-php option.

Validation

PE1

Verify ISIS neighbor adjacency between routers.

```
PE1#sh clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag isis1: VRF : default
System Id      Interface  SNPA                State  Holdtime  Type Protocol
P1              eth2      5254.008b.368d      Up     8          L1   IS-IS
                eth2      5254.008b.368d      Up     8          L2   IS-IS
P2              eth3      5254.0098.900b      Up     23         L1   IS-IS
                eth3      5254.0098.900b      Up     23         L2   IS-IS

P1#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 3
Total number of adjacencies: 6
Tag isis1: VRF : default
System Id      Interface  SNPA                State  Holdtime  Type Protocol
```

```

P2          eth1          5254.00de.ca03      Up    5      L1    IS-IS
           Up            5                L2    IS-IS
PE1         eth2          5254.0060.8a75      Up    27     L1    IS-IS
           Up            27            L2    IS-IS
PE3         eth4          5254.0085.7e32      Up    5      L1    IS-IS
           Up            5                L2    IS-IS

P2#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 3
Total number of adjacencies: 6
Tag isis1: VRF : default
System Id      Interface  SNPA          State Holdtime  Type Protocol
P1             eth1      5254.00a6.9153 Up    28        L1    IS-IS
           Up            28        L2    IS-IS
PE1            eth3      5254.00ac.d346 Up    6         L1    IS-IS
           Up            6         L2    IS-IS
PE4            eth4      5254.00c8.98db Up    6         L1    IS-IS
           Up            6         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 isis1: VRF : default
System Id      Interface  SNPA          State Holdtime  Type Protocol
PE4            eth1      5254.0007.09e5 Up    26        L1    IS-IS
           Up            26        L2    IS-IS
P1             eth4      5254.000d.673d Up    26        L1    IS-IS
           Up            26        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 isis1: VRF : default
System Id      Interface  SNPA          State Holdtime  Type Protocol
PE3            eth1      5254.00d0.4baf Up    8         L1    IS-IS
           Up            8         L2    IS-IS
P2             eth4      5254.0011.6e77 Up    20        L1    IS-IS
           Up            20        L2    IS-IS

```

P1

The command output below displays the details of routers configured with segment routing.

```

P1#show isis segment-routing capability

Tag isis1 Segment-Routing:
-----
Advertisement Router Capability :10.0.1.11
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :10.0.1.1
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :6501
SID Range List Count           :1
SID's Range                    :17000 - 23500

```

```

-----
Advertisement Router Capability :10.0.1.33
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :4501
SID Range List Count           :1
SID's Range                    :17500 - 22000
-----
Advertisement Router Capability :10.0.1.44
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :6000
SID Range List Count           :1
SID's Range                    :18000 - 23999
-----
Advertisement Router Capability :10.0.1.2
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :6001
SID Range List Count           :1
SID's Range                    :16500 - 22500
-----

```

P1

Verify that segment routing information is present in ISIS database.

```

P1#show isis database verbose
Tag isis1: VRF : default
IS-IS Level-1 Link State Database:
LSPID      LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
P1.00-00   * 0x00000015  0x0E94       1137         0/0/0
  Area Address: 49.0000
  NLPID:       0xCC
  Hostname:    P1
  IP Address:  10.0.1.1
  Router ID:   10.0.1.1
  Router Cap:  10.0.1.1
    SRGB Range: 6501   SRGB Base SID: 17000   I:1 V:0
    SR-Algorithm:
      Algorithm: 0
  Metric:      10      IS-Extended PE3.03
  IPv4 Interface Address: 10.33.1.2
  Neighbor IP Address: 10.33.1.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1033 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
  Metric:      10      IS-Extended P1.03
  IPv4 Interface Address: 10.11.1.2
  Neighbor IP Address: 10.11.1.2
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m

```



```

    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IS-Extended P2.02
    IPv4 Interface Address: 10.1.2.1
    Neighbor IP Address: 10.1.2.2
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
        Unreserved Bandwidth at priority 0: 100m
        Unreserved Bandwidth at priority 1: 100m
        Unreserved Bandwidth at priority 2: 100m
        Unreserved Bandwidth at priority 3: 100m
        Unreserved Bandwidth at priority 4: 100m
        Unreserved Bandwidth at priority 5: 100m
        Unreserved Bandwidth at priority 6: 100m
        Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1002 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 10.0.1.1/32
    Prefix-SID: index 200 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 10 IP-Extended 10.1.2.0/30
    Metric: 10 IP-Extended 10.11.1.0/30
    Metric: 10 IP-Extended 10.33.1.0/30
    P1.03-00 * 0x0000000D 0xBFBA 1133 0/0/0
    Metric: 0 IS-Extended P1.00
    Metric: 0 IS-Extended PE1.00
    P2.00-00 0x00000015 0x70EC 1136 0/0/0
    Area Address: 49.0000
    NLPID: 0xCC
    Hostname: P2
    IP Address: 10.0.1.2
    Router ID: 10.0.1.2
    Router Cap: 10.0.1.2
    SRGB Range: 6001 SRGB Base SID: 16500 I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10 IS-Extended P2.02
    IPv4 Interface Address: 10.1.2.2
    Neighbor IP Address: 10.1.2.2
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
        Unreserved Bandwidth at priority 0: 100m
        Unreserved Bandwidth at priority 1: 100m
        Unreserved Bandwidth at priority 2: 100m
        Unreserved Bandwidth at priority 3: 100m
        Unreserved Bandwidth at priority 4: 100m
        Unreserved Bandwidth at priority 5: 100m
        Unreserved Bandwidth at priority 6: 100m
        Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IS-Extended PE1.04
    IPv4 Interface Address: 10.11.2.2
    Neighbor IP Address: 10.11.2.1
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
        Unreserved Bandwidth at priority 0: 100m
        Unreserved Bandwidth at priority 1: 100m
        Unreserved Bandwidth at priority 2: 100m

```

```

    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE4.03
IPv4 Interface Address: 10.44.2.2
Neighbor IP Address: 10.44.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1044 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.2/32
Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.1.24.0/24
Metric: 10 IP-Extended 10.11.2.0/30
Metric: 10 IP-Extended 10.44.2.0/30
P2.02-00 0x0000000D 0x8603 1132 0/0/0
Metric: 0 IS-Extended P2.00
Metric: 0 IS-Extended P1.00
PE1.00-00 0x00000013 0xE7E5 1136 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE1
IP Address: 10.0.1.11
Router ID: 10.0.1.11
Router Cap: 10.0.1.11
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
    Algorithm: 0
Metric: 10 IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.1
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 26241 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P1.03
IPv4 Interface Address: 10.11.1.1
Neighbor IP Address: 10.11.1.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m

```

```

    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1001 LAN Adjacency SID: 26240 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 10.0.1.11/32
    Prefix-SID: index 100 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 10 IP-Extended 10.11.1.0/30
    Metric: 10 IP-Extended 10.11.2.0/30
    PE1.04-00 0x0000000D 0x9BCC 1132 0/0/0
    Metric: 0 IS-Extended PE1.00
    Metric: 0 IS-Extended P2.00
    PE3.00-00 0x00000013 0x476C 1136 0/0/0
    Area Address: 49.0000
    NLPID: 0xCC
    Hostname: PE3
    IP Address: 10.0.1.33
    Router ID: 10.0.1.33
    Router Cap: 10.0.1.33
    SRGB Range: 4501 SRGB Base SID: 17500 I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10 IS-Extended PE3.02
    IPv4 Interface Address: 10.33.44.1
    Neighbor IP Address: 10.33.44.1
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1044 LAN Adjacency SID: 24960 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IS-Extended PE3.03
    IPv4 Interface Address: 10.33.1.1
    Neighbor IP Address: 10.33.1.1
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1001 LAN Adjacency SID: 24961 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 10.0.1.33/32
    Prefix-SID: index 500 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 10 IP-Extended 10.33.44.0/30
    Metric: 10 IP-Extended 10.33.1.0/30
    Metric: 10 IP-Extended 10.1.45.0/24
    PE3.02-00 0x0000000C 0xFAE9 1132 0/0/0
    Metric: 0 IS-Extended PE3.00
    Metric: 0 IS-Extended PE4.00
    PE3.03-00 0x0000000D 0xB075 1132 0/0/0
    Metric: 0 IS-Extended PE3.00
    Metric: 0 IS-Extended P1.00
    PE4.00-00 0x00000012 0xD15B 1136 0/0/0
    Area Address: 49.0000

```

```

NLPID:      0xCC
Hostname:    PE4
IP Address:  10.0.1.44
Router ID:   10.0.1.44
Router Cap:  10.0.1.44
  SRGB Range: 6000   SRGB Base SID: 18000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10      IS-Extended PE3.02
  IPv4 Interface Address: 10.33.44.2
  Neighbor IP Address: 10.33.44.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1033 LAN Adjacency SID: 25600   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended PE4.03
  IPv4 Interface Address: 10.44.2.1
  Neighbor IP Address: 10.44.2.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1002 LAN Adjacency SID: 25601   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IP-Extended 10.0.1.44/32
  Prefix-SID: index 600 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10      IP-Extended 10.33.44.0/30
Metric: 10      IP-Extended 10.44.2.0/30
Metric: 10      IP-Extended 10.1.36.0/24
PE4.03-00      0x0000000C   0xD72C   1132   0/0/0
Metric: 0      IS-Extended PE4.00
Metric: 0      IS-Extended P2.00

IS-IS Level-2 Link State Database:
LSPID      LSP Seq Num   LSP Checksum   LSP Holdtime   ATT/P/OL
P1.00-00   * 0x0000001F   0xBE3D        1148           0/0/0
  Area Address: 49.0000
  NLPID:      0xCC
  Hostname:    P1
  IP Address:  10.0.1.1
  Router ID:   10.0.1.1
  Router Cap:  10.0.1.1
  SRGB Range: 6501   SRGB Base SID: 17000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10      IS-Extended PE3.03
  IPv4 Interface Address: 10.33.1.2
  Neighbor IP Address: 10.33.1.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m

```

```

    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1033 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P1.03
IPv4 Interface Address: 10.11.1.2
Neighbor IP Address: 10.11.1.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P2.02
IPv4 Interface Address: 10.1.2.1
Neighbor IP Address: 10.1.2.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1002 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.1/32
Prefix-SID: index 200 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.11.1.0/30
Metric: 10 IP-Extended 10.33.1.0/30
Metric: 20 IP-Extended 10.0.1.2/32
Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.33/32
Prefix-SID: index 500 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20 IP-Extended 10.1.24.0/24
Metric: 20 IP-Extended 10.1.45.0/24
Metric: 20 IP-Extended 10.11.2.0/30
Metric: 20 IP-Extended 10.33.44.0/30
Metric: 20 IP-Extended 10.44.2.0/30
Metric: 20 IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 30 IP-Extended 10.0.1.44/32
Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30 IP-Extended 10.1.36.0/24
P1.03-00 * 0x0000000C 0xC1B9 1133 0/0/0
Metric: 0 IS-Extended P1.00
Metric: 0 IS-Extended PE1.00
P2.00-00 0x00000020 0xB0EE 1147 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P2
IP Address: 10.0.1.2

```

```
Router ID: 10.0.1.2
Router Cap: 10.0.1.2
  SRGB Range: 6001   SRGB Base SID: 16500   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10          IS-Extended P2.02
  IPv4 Interface Address: 10.1.2.2
  Neighbor IP Address: 10.1.2.2
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1001   LAN Adjacency SID: 24320   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE1.04
  IPv4 Interface Address: 10.11.2.2
  Neighbor IP Address: 10.11.2.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1011   LAN Adjacency SID: 24321   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE4.03
  IPv4 Interface Address: 10.44.2.2
  Neighbor IP Address: 10.44.2.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1044   LAN Adjacency SID: 24322   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 10.0.1.2/32
  Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 10.1.2.0/30
Metric: 10          IP-Extended 10.1.24.0/24
Metric: 10          IP-Extended 10.11.2.0/30
Metric: 10          IP-Extended 10.44.2.0/30
Metric: 20          IP-Extended 10.0.1.11/32
  Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20          IP-Extended 10.0.1.44/32
  Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20          IP-Extended 10.1.36.0/24
Metric: 20          IP-Extended 10.11.1.0/30
Metric: 20          IP-Extended 10.33.44.0/30
Metric: 20          IP-Extended 10.0.1.1/32
  Prefix-SID: index 200 R:1 N:0 P:0 E:0 V:0 L:0
```

```

Metric: 30          IP-Extended 10.0.1.33/32
  Prefix-SID: index 500 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 30          IP-Extended 10.1.45.0/24
Metric: 20          IP-Extended 10.33.1.0/30
P2.02-00           0x0000000C  0x8802          1132          0/0/0
Metric: 0           IS-Extended P2.00
Metric: 0           IS-Extended P1.00
PE1.00-00           0x0000001E  0xD679          1147          0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE1
IP Address: 10.0.1.11
Router ID: 10.0.1.11
Router Cap: 10.0.1.11
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10          IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.1
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 26241 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended P1.03
IPv4 Interface Address: 10.11.1.1
Neighbor IP Address: 10.11.1.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 26240 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 10.0.1.11/32
  Prefix-SID: index 100 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10          IP-Extended 10.11.1.0/30
Metric: 10          IP-Extended 10.11.2.0/30
Metric: 20          IP-Extended 10.0.1.1/32
  Prefix-SID: index 200 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20          IP-Extended 10.1.2.0/30
Metric: 20          IP-Extended 10.33.1.0/30
Metric: 20          IP-Extended 10.0.1.2/32
  Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30          IP-Extended 10.0.1.33/32
  Prefix-SID: index 500 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 30          IP-Extended 10.0.1.44/32
  Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20          IP-Extended 10.1.24.0/24
Metric: 30          IP-Extended 10.1.36.0/24
Metric: 30          IP-Extended 10.1.45.0/24
Metric: 30          IP-Extended 10.33.44.0/30
Metric: 20          IP-Extended 10.44.2.0/30

```

```

PE1.04-00          0x0000000B  0x9FCA      1132      0/0/0
  Metric:    0      IS-Extended PE1.00
  Metric:    0      IS-Extended PE2.00
PE3.00-00          0x0000001E  0xFAAF      1147      0/0/0
  Area Address: 49.0000
  NLPID:      0xCC
  Hostname:   PE3
  IP Address: 10.0.1.33
  Router ID:  10.0.1.33
  Router Cap: 10.0.1.33
    SRGB Range: 4501   SRGB Base SID: 17500   I:1 V:0
    SR-Algorithm:
      Algorithm: 0
  Metric:    10      IS-Extended PE3.02
  IPv4 Interface Address: 10.33.44.1
  Neighbor IP Address: 10.33.44.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1044 LAN Adjacency SID: 24960   F:0 B:0 V:1 L:1 S:0 P:0
  Metric:    10      IS-Extended PE3.03
  IPv4 Interface Address: 10.33.1.1
  Neighbor IP Address: 10.33.1.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1001 LAN Adjacency SID: 24961   F:0 B:0 V:1 L:1 S:0 P:0
  Metric:    10      IP-Extended 10.0.1.33/32
    Prefix-SID: index 500 R:0 N:1 P:0 E:0 V:0 L:0
  Metric:    10      IP-Extended 10.33.44.0/30
  Metric:    10      IP-Extended 10.33.1.0/30
  Metric:    10      IP-Extended 10.1.45.0/24
  Metric:    20      IP-Extended 10.0.1.1/32
    Prefix-SID: index 200 R:1 N:0 P:0 E:0 V:0 L:0
  Metric:    30      IP-Extended 10.0.1.2/32
    Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
  Metric:    30      IP-Extended 10.0.1.11/32
    Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
  Metric:    20      IP-Extended 10.0.1.44/32
    Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
  Metric:    20      IP-Extended 10.1.2.0/30
  Metric:    30      IP-Extended 10.1.24.0/24
  Metric:    20      IP-Extended 10.1.36.0/24
  Metric:    20      IP-Extended 10.11.1.0/30
  Metric:    30      IP-Extended 10.11.2.0/30
  Metric:    20      IP-Extended 10.44.2.0/30
PE3.02-00          0x0000000B  0xFCE8      1132      0/0/0
  Metric:    0      IS-Extended PE3.00
  Metric:    0      IS-Extended PE4.00
PE3.03-00          0x0000000C  0xB274      1132      0/0/0

```



```

Metric: 0          IS-Extended PE3.00
Metric: 0          IS-Extended P1.00
PE4.00-00          0x0000001F  0x7C42      1147      0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE4
IP Address: 10.0.1.44
Router ID: 10.0.1.44
Router Cap: 10.0.1.44
  SRGB Range: 6000   SRGB Base SID: 18000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10         IS-Extended PE3.02
IPv4 Interface Address: 10.33.44.2
Neighbor IP Address: 10.33.44.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1033 LAN Adjacency SID: 25600 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IS-Extended PE4.03
IPv4 Interface Address: 10.44.2.1
Neighbor IP Address: 10.44.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 25601 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IP-Extended 10.0.1.44/32
Prefix-SID: index 600 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10         IP-Extended 10.33.44.0/30
Metric: 10         IP-Extended 10.44.2.0/30
Metric: 10         IP-Extended 10.1.36.0/24
Metric: 20         IP-Extended 10.0.1.33/32
Prefix-SID: index 500 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20         IP-Extended 10.1.45.0/24
Metric: 20         IP-Extended 10.33.1.0/30
Metric: 30         IP-Extended 10.0.1.1/32
Prefix-SID: index 200 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20         IP-Extended 10.0.1.2/32
Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30         IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20         IP-Extended 10.1.2.0/30
Metric: 20         IP-Extended 10.1.24.0/24
Metric: 30         IP-Extended 10.11.1.0/30
Metric: 20         IP-Extended 10.11.2.0/30
PE4.03-00          0x0000000B  0xD92B      1132      0/0/0
Metric: 0          IS-Extended PE4.00
Metric: 0          IS-Extended P2.00

```

Validation 4

Verify that segment routing is enabled and that prefix SIDs are announced to other routers.

Verify that prefix SIDs are installed as labels in MPLS forwarding table. Verify the same in FTN and ILM tables.

```
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	Nexthop	FTN-ID	Nhlfe-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	ELC								
i>	10.0.1.2/32		1	4	0	Yes	LSP_		
DEFAULT	16800	eth1	No	10.1.2.2					
i>	10.0.1.11/32		3	2	0	Yes	LSP_		
DEFAULT	3	eth2	No	10.11.1.1					
i>	10.0.1.33/32		2	1	0	Yes	LSP_		
DEFAULT	3	eth4	No	10.33.1.1					
i>	10.0.1.44/32		4	5	0	Yes	LSP_		
DEFAULT	17100	eth1	No	10.1.2.2					

In the forwarding tables above, the configured prefix SIDs are in the Out-Label column which is expected and is global across the topology. The swap happens in between nodes with this prefix SID and there is no local labelling.

Also verify the ILM and FTN tables.

```
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			
i>	10.33.1.1/32	18	24320	3	N/A	eth4
.1.1		LSP_DEFAULT				10.33
i>	10.0.1.2/32	21	17300	16800	N/A	eth1
2.2		LSP_DEFAULT				10.1.
i>	10.0.1.1/32	17	17200	NoLabel	N/A	N/A
.0.1		LSP_DEFAULT				127.0
i>	10.0.1.11/32	23	17100	3	N/A	eth2
.1.1		LSP_DEFAULT				10.11
i>	10.0.1.33/32	22	17500	3	N/A	eth4
.1.1		LSP_DEFAULT				10.33
i>	10.0.1.44/32	24	17600	17100	N/A	eth1
2.2		LSP_DEFAULT				10.1.
i>	10.11.1.1/32	19	24321	3	N/A	eth2
.1.1		LSP_DEFAULT				10.11
i>	10.1.2.2/32	20	24322	3	N/A	eth1
2.2		LSP_DEFAULT				10.1.

```
P1#show mpls ftn-table
```

```
Primary FTN entry with FEC: 10.0.1.2/32, id: 1, row status: Active
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 4
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16800
Nexthop addr: 10.1.2.2 cross connect ix: 6, op code: Push
```

```
Primary FTN entry with FEC: 10.0.1.11/32, id: 3, row status: Active
```

```
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
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: eth2, out label: 3
  Nexthop addr: 10.11.1.1          cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 2, row status: Active
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
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: eth4, out label: 3
  Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 4, row status: Active
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP 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: 5
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 5, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 17100
  Nexthop addr: 10.1.2.2          cross connect ix: 7, op code: Push

Pl#show mpls in-segment-table
Owner: ISIS-SR, # of pops: 1, fec: 10.33.1.1/32, ILM-ID: 18
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 24320 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: eth4, out label: 3
  Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 21
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 6, in intf: - in label: 17300 out-segment ix: 4
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 4, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16800
  Nexthop addr: 10.1.2.2          cross connect ix: 6, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.1/32, ILM-ID: 17
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 17200 out-segment ix: 0
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
  Nexthop addr: 127.0.0.1          cross connect ix: 1, op code: Pop

Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 23
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 3, in intf: - in label: 17100 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: eth2, out label: 3
  Nexthop addr: 10.11.1.1          cross connect ix: 3, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 22
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
```

```
Cross connect ix: 1, in intf: - in label: 17500 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: eth4, out label: 3
  Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.44/32, ILM-ID: 24
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
  Cross connect ix: 7, in intf: - in label: 17600 out-segment ix: 5
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 5, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 17100
  Nexthop addr: 10.1.2.2          cross connect ix: 7, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.11.1.1/32, ILM-ID: 19
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
  Cross connect ix: 3, in intf: - in label: 24321 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: eth2, out label: 3
  Nexthop addr: 10.11.1.1          cross connect ix: 3, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.1.2.2/32, ILM-ID: 20
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
  Cross connect ix: 5, in intf: - in label: 24322 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: eth1, out label: 3
  Nexthop addr: 10.1.2.2          cross connect ix: 5, op code: Swap

P1#show mpls out-segment-table
  Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: eth2, out label: 3
  Nexthop addr: 10.11.1.1          cross connect ix: 3, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

  Out-segment with ix: 4, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16800
  Nexthop addr: 10.1.2.2          cross connect ix: 6, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

  Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: eth1, out label: 3
  Nexthop addr: 10.1.2.2          cross connect ix: 5, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

  Out-segment with ix: 5, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 17100
  Nexthop addr: 10.1.2.2          cross connect ix: 7, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

  Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: eth4, out label: 3
  Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0
```

Segment Routing Ping and Traceroute

Segment Routing Ping

The MPLS LSP ping feature is used to check the connectivity between ingress and egress of LSP. MPLS LSP ping uses MPLS echo request and reply messages, similar to Internet Control Message Protocol (ICMP) echo request and reply messages, to validate an LSP.

Segment routing ping is an extension of the MPLS LSP ping to perform the connectivity verification on the segment routing control plane.

Segment Routing ping can use either generic FEC type or SR control-plane FEC type (ISIS-SR or OSPF-SR)

Segment Routing Trace

The MPLS LSP traceroute is used to isolate the failure point of an LSP. It is used for hop-by-hop fault localization and path tracing. The MPLS LSP traceroute feature relies on the expiration of the Time to Live (TTL) value of the packet that carries the echo request.

Similar to segment routing ping, you can initiate the segment routing traceroute operation only when Segment Routing control plane is available at the originator

Segment Routing traceroute can use either generic FEC type or SR control-plane FEC type (OSPF-SR or ISIS-SR).

See [Figure 3](#).

Validation

These examples show how to use segment routing ping to test the connectivity of a segment routing control plane and segment routing trace to trace LSP of specified Prefix SID.

Ping with other options.

Detail

Validation on Detail

```
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.33.1.1 2.41 ms! seq_num = 2 10.33.1.1 1.06 ms! seq_num = 3 10.33.1.1 1.11 ms!
seq_num = 4 10.33.1.1 1.67 ms! seq_num = 5 10.33.1.1 1.07 ms

Success Rate is 100.00 percent (5/5) round-trip min/avg/max = 1.06/1.74/2.41
```

Destination

Validation on Destination

```
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 destination 127.1.0.1 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.33.1.1 1.60 ms! seq_num = 2 10.33.1.1 1.22 ms! seq_num = 3 10.33.1.1 1.37 ms!
seq_num = 4 10.33.1.1 1.38 ms! seq_num = 5 10.33.1.1 1.52 ms

Success Rate is 100.00 percent (5/5) round-trip min/avg/max = 1.22/1.41/1.60

```

Source 1

Validation on Source

```

PE1#ping mpls isis-sr ipv4 10.0.1.33/32 destination 127.1.0.1 source 10.0.1.11 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.33.1.1 1.97 ms! seq_num = 2 10.33.1.1 1.26 ms! seq_num = 3 10.33.1.1 1.50 ms!
seq_num = 4 10.33.1.1 1.46 ms! seq_num = 5 10.33.1.1 1.35 ms

Success Rate is 100.00 percent (5/5) round-trip min/avg/max = 1.26/1.62/1.97

```

Source 2

Validation on Source

```

PE1#ping mpls isis-sr ipv4 10.0.1.33/32 ?
destination Destination
detail detailed output
flags Validate Fec
force-explicit-null Force Explicit NULL label
interval Interval
repeat Count
reply-mode Reply-mode
source source
timeout Timeout of ping
ttl Time-to-live
<cr>
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 flags ?
destination Destination
detail detailed output
force-explicit-null Force Explicit NULL label
interval Interval
repeat Count
reply-mode Reply-mode
source source
timeout Timeout of ping
ttl Time-to-live
<cr>
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 flags de?
destination Destination
detail detailed output

```

```
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 flags detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.33.1.1 1.76 ms
! seq_num = 2 10.33.1.1 1.20 ms
! seq_num = 3 10.33.1.1 1.32 ms
! seq_num = 4 10.33.1.1 1.06 ms
! seq_num = 5 10.33.1.1 1.23 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.06/1.41/1.76
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 timeout 500 detail
Sending 5 MPLS Echos to 10.0.1.33, timeout is 500 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 10.33.1.1 2.12 ms
! seq_num = 2 10.33.1.1 1.41 ms
! seq_num = 3 10.33.1.1 1.55 ms
! seq_num = 4 10.33.1.1 1.60 ms
! seq_num = 5 10.33.1.1 1.37 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.37/1.75/2.12
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 repeat 10 detail
Sending 10 MPLS Echos to 10.0.1.33, 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 10.33.1.1 2.46 ms
! seq_num = 2 10.33.1.1 1.73 ms
! seq_num = 3 10.33.1.1 1.61 ms
! seq_num = 4 10.33.1.1 1.74 ms
! seq_num = 5 10.33.1.1 1.98 ms
! seq_num = 6 10.33.1.1 1.59 ms
! seq_num = 7 10.33.1.1 1.75 ms
! seq_num = 8 10.33.1.1 2.07 ms
! seq_num = 9 10.33.1.1 1.83 ms
! seq_num = 10 10.33.1.1 1.82 ms
Success Rate is 100.00 percent (10/10)
round-trip min/avg/max = 1.59/2.02/2.46
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 interval 10000 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.33.1.1 1.81 ms
! seq_num = 2 10.33.1.1 2.02 ms
! seq_num = 3 10.33.1.1 1.90 ms
! seq_num = 4 10.33.1.1 1.83 ms
! seq_num = 5 10.33.1.1 6.84 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.81/4.32/6.84
PE1#ping mpls isis-sr ipv4 10.0.1.33/32 ttl 225 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.33.1.1 2.21 ms
! seq_num = 2 10.33.1.1 1.50 ms
! seq_num = 3 10.33.1.1 1.34 ms
! seq_num = 4 10.33.1.1 1.61 ms
! seq_num = 5 10.33.1.1 1.36 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.34/1.78/2.21
=====
TRACEROUTE
=====
PE1#trace mpls isis-sr ipv4 10.0.1.33/32 detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels: 17500]
R 1 10.11.1.2 [Labels: ] 2.00 ms
! 2 10.33.1.1 2.31 ms
PE1#trace mpls isis-sr ipv4 10.0.1.33/32 destination 127.1.0.1 detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels: 17500]
R 1 10.11.1.2 [Labels: ] 1.22 ms
! 2 10.33.1.1 1.61 ms
PE1#trace mpls isis-sr ipv4 10.0.1.33/32 destination 127.1.0.1 source 10.0.1.11 detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels: 17500]
R 1 10.11.1.2 [Labels: ] 1.26 ms
! 2 10.33.1.1 1.74 ms
PE1#trace mpls isis-sr ipv4 10.0.1.33/32 flags detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels: 17500]
R 1 10.11.1.2 [Labels: ] 0.98 ms
! 2 10.33.1.1 1.35 ms
PE1#trace mpls isis-sr ipv4 10.0.1.33/32 reply-mode 2 detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels: 17500]
R 1 10.11.1.2 [Labels: ] 1.34 ms
! 2 10.33.1.1 1.87 ms

```

Flex Algorithm for ISIS

Flexible Algorithms (Flex-Algo) is a cutting-edge enhancement within Segment Routing (SR) technology, enabling customized path computation within Interior Gateway Protocols (IGP) protocols like IS-IS. This feature supports diverse traffic engineering needs, such as low latency or bandwidth optimization, without external controllers. Flex-Algo creates logical routing planes within an IGP, enabling constrained traffic paths tailored to application-specific requirements. This makes it a key component in networks supporting modern services, including 5G.



Note: Currently, OcNOS supports this feature for IS-IS as the IGP.

ISIS Flexible Algorithms

Traditional IGPs, using Shortest Path First (SPF) computations, limit flexibility by routing traffic solely based on link costs. This results in static traffic patterns, leading to underutilization of network resources and an inability to meet specific requirements, such as latency minimization or link exclusion.

While solutions like MPLS-TE addresses these challenges, they introduce complexity, scalability issues, and increased operational overhead. Flex-Algo simplifies traffic engineering by allowing operators to define routing rules directly within the IGP. This enables efficient handling of traffic for diverse applications, particularly in the 5G era, where flexibility is crucial.

Feature Characteristics

Flex-Algo Definition

Flex-Algo allows the creation of up to 128 unique algorithms, each operating independently. Key parameters defining a Flex-Algo include:

Path Computation Method

- **Standard SPF:** Uses the Dijkstra algorithm for shortest path computation and allows policy-driven modifications.
- **Strict SPF:** Similar to Standard SPF but restricts policy-based adjustments.

Routing Metrics

- **IGP Metric:** Based on traditional link costs as defined in the IGP.
- **Traffic Engineering (TE) Metric:** Optimizes paths using TE attributes like bandwidth and utilization.
- **Link Delay:** Routes traffic based on the lowest unidirectional delay.

Priority Levels

- Algorithms are processed based on their priority value.
- In cases of identical priority, the System-ID acts as a tiebreaker and selects the advertisement with the highest System-ID.

Link Affinity Constraints

Defines constraints for path computation, using affinity attributes configured as Administrative Groups (AG) or Extended Administrative Groups (EAG):

- **Forward EAG Exclude Any:** Excludes links with any matching affinity bits.
- **Forward EAG Include Any:** Includes links with at least one matching affinity bit.
- **Forward EAG Include All:** Includes links only if all specified affinity bits match.
- **Reverse EAG Exclude Any:** Excludes links from reverse path computation if any matching affinity bits are found.
- **Reverse EAG Include Any:** Includes links if at least one affinity bit matches.
- **Reverse EAG Include All:** Includes links only if all affinity bits match.

Delay Constraints

Routes traffic over low-delay links using metrics collected via protocols like TWAMP, optimizing latency-sensitive applications.

Participation in a Flexible Algorithm

Flex-Algo Support Advertisement

Routers advertise support for specific Flex-Algos using IGP. Algorithm values (128–255) are tightly coupled with Prefix-SIDs, enabling algorithm-specific forwarding. Operators configure routers to participate in algorithms based on network requirements.

Flex-Algo Definition Advertisement

To ensure loop-free forwarding, routers in the network must share a consistent algorithm definition. Routers advertise these definitions, including metrics and affinity constraints, using a priority mechanism.

Recommendations include:

At least one router per area must advertise the algorithm definition. Configuring two routers ensures redundancy. Without a valid algorithm definition advertisement, Flex-Algo cannot function.

Flex-Algo Prefix-SID Advertisement

Routers participating in a Flex-Algo advertise MPLS-labeled paths associated with the algorithm's Prefix-SID. Prefix-SIDs are specific to the algorithm and enable algorithm-driven forwarding. Rules include:

- Only prefixes associated with an algorithm-specific Prefix-SID are included in the forwarding table.
- Prefix-SIDs and prefixes can be leaked between areas but are limited to reachable Layer 1 or Layer 2 routers.

Path Calculation and Forwarding Entries

Path Calculation

- Nodes not supporting the algorithm are excluded.
- Links with excluded affinities are pruned from the topology.
- Only links advertising the algorithm's required metric are considered.

Forwarding Entries

- Paths must be installed using the Prefix-SID advertised for the algorithm.
- If no Prefix-SID is available, the path is not installed in the forwarding table.
- Routes for each algorithm are installed in algorithm-specific RIB groups. By default, IS-IS Flex-Algo routes are added to MPLS RIBs.

Example of Flex-Algo Path Calculation

Nodes and Links

- The topology consists of 6 nodes (1, 2, 3, 4, 5, and 6).
- Each link is assigned:
 - Cost (IGP Metric): Default is 10.

- Delay (TE Metric): Some links (for example: Node 1 to Node 5 and Node 5 to Node 6) have a delay of 6, while others have a delay of 10.

Flex-Algo 0 (Default Algorithm)

- Uses cost (IGP metric) as the path computation metric.
- Considers all links in the network (no exclusions based on affinities).
- Equal-cost paths are possible due to the uniform cost across links.

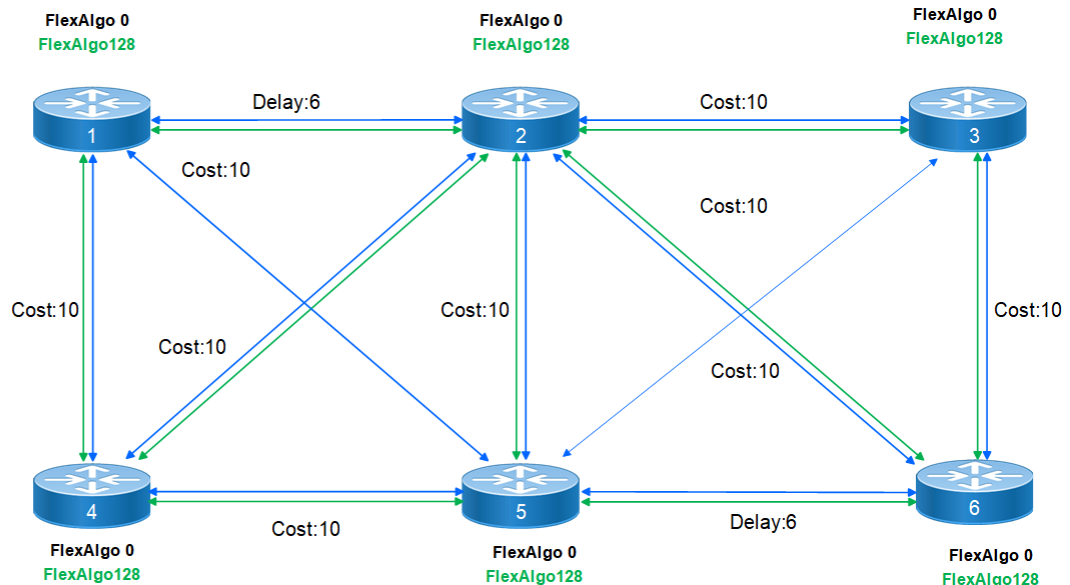
Flex-Algo 128 (Custom Algorithm)

- Uses delay (TE metric) for path computation.
- Includes only links marked with the green affinity attribute.
- Excludes all other links from the topology unless they meet the "green" affinity condition.

Overview of Both Algorithms

- Shows how both Flex-Algo 0 (blue) and Flex-Algo 128 (green) are configured within the same topology.
- Links supporting Flex-Algo 128 are marked in green and constrained by the green affinity attribute.

Figure 4. Flex-Algo 0 Topology



- All links are included in this topology, as Flex-Algo 0 uses IGP metrics and has no constraints.
- Path Example: For traffic from Node 1 to Node 3, the paths are:
 - Node 1 → Node 2 → Node 3.
 - Node 1 → Node 5 → Node 3.
- Both paths are valid since the total cost for each path is equal (20).

Figure 5. Flex-Algo 0 Topology

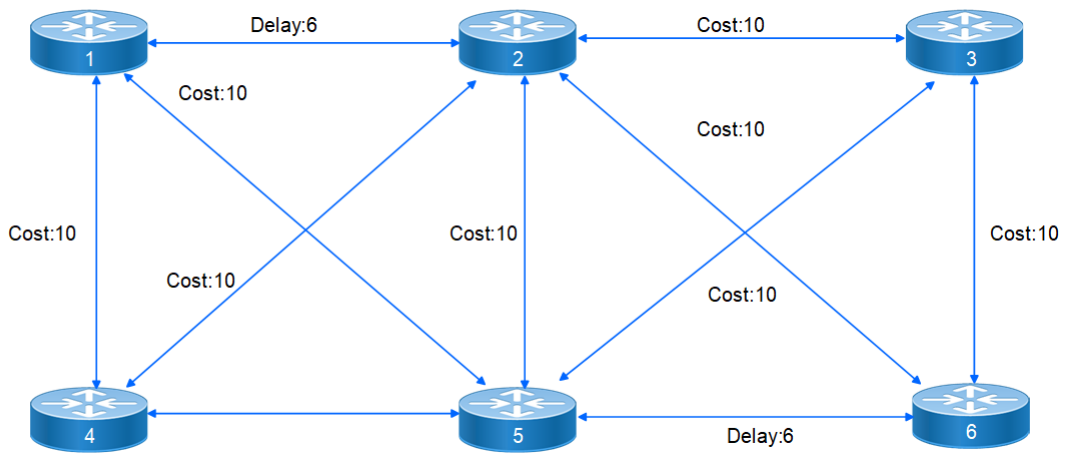
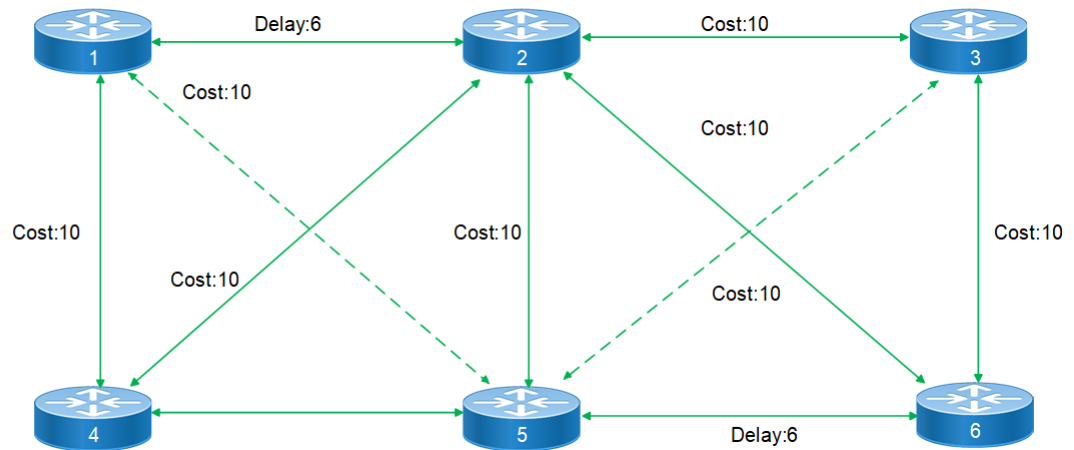


Figure 6. Flex-Algo 128 Topology



- Only includes links with the green affinity attribute.
- Some links (for example: Node 1 → Node 4, Node 4 → Node 5) are excluded because they do not have the required affinity.
- Path Example: For traffic from Node 1 to Node 3, the only valid path is:
 - Node 1 → Node 2 → Node 3.
 - This path is selected because it minimizes delay (TE metric) while satisfying the "green" affinity constraint.

Key Observations

Flex-Algo 0

- Suitable for general-purpose routing without any specific constraints.
- Uses cost as the metric, enabling equal-cost path computation.

Flex-Algo 128

- Optimized for delay-sensitive traffic, focusing on paths with minimal delay.

- Excludes links without the green affinity, reducing the available topology and forcing path selection based on both constraints and delay.

Benefits

Flex-Algo introduces significant advantages for network operations:

- Tailored Path Selection: Enables customization of routing paths to meet specific traffic and application requirements, such as low latency or high throughput.
- Integrated Traffic Engineering: Embeds traffic engineering capabilities within IGPs, reducing reliance on external controllers.
- Optimized Network Resources: Improves utilization by avoiding congestion and ensuring balanced traffic distribution.
- Simplified Operations: Reduces the complexity of traditional configurations, such as MPLS-TE, while maintaining scalability for modern networks.

Prerequisites

- Devices must support IS-IS with Segment Routing and Flex-Algo capabilities.
- IGP and SR configurations must be enabled on all participating routers.
- Prefix-SIDs must be assigned for each Flex-Algo.
- Affinity groups (AG or EAG) should be pre-configured to define link constraints.
- Traffic Engineering and SR configurations must be enabled to advertise Sub-TLVs.

Configuration

The following configuration enables Flex Algo with ISIS-SR.

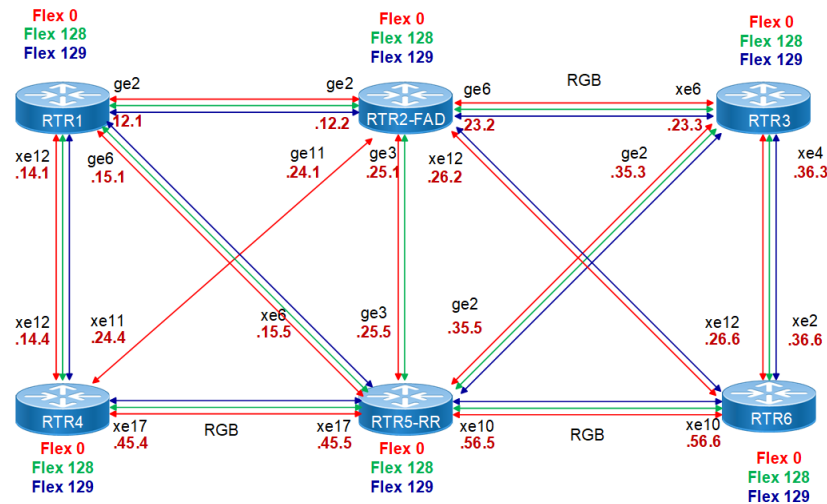
Topology

This topology represents the application of Flex-Algo in a SR network environment, with three distinct algorithms highlighted: Flex Algo 0, Flex Algo 128, and Flex Algo 129. Each algorithm defines a specific logical topology based on unique constraints and use cases.

Topology Visualization

- Red Lines (Flex Algo 0): Represents the default IGP metric-based paths where all links contribute to general traffic forwarding.
- Green Lines (Flex Algo 128): Highlights paths optimized for bandwidth efficiency using GREEN-affinity links, filtering out non-compliant links.
- Blue Lines (Flex Algo 129): Displays paths optimized for delay-sensitive traffic using BLUE-affinity links, excluding all others.

Figure 7. Logical Topologies Based on Flexible Algorithms



Default IGP Metric-Based Topology (FlexAlgo 0)

This topology uses the standard IGP metrics for shortest-path computation.

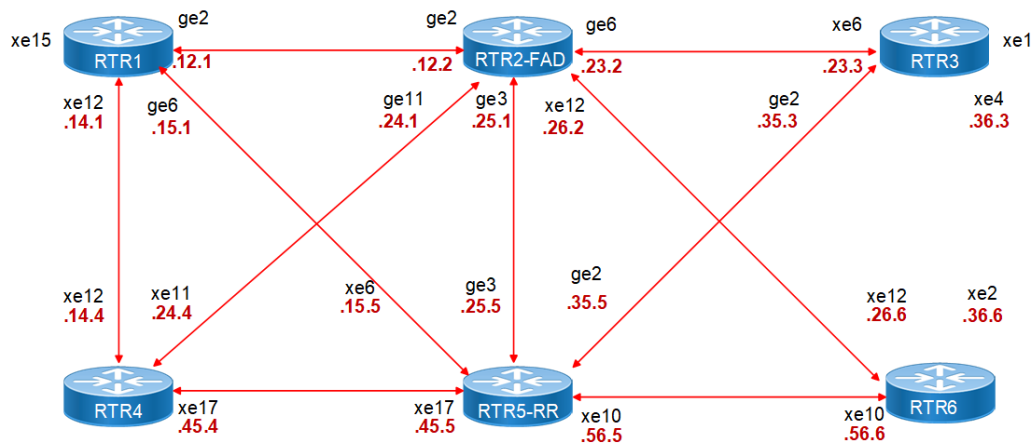
Metrics for links default to 10, unless explicitly modified.

Logical Representation: Includes all routers and links in the network. Designed to provide a generic network topology without special constraints or optimizations.

Use Case: Suitable for non-critical, general-purpose traffic. Lacks any special optimization for delay, bandwidth, or other constraints.

Example: Basic network connectivity for general applications like email or web browsing, where performance is not a critical factor.

Figure 8. Default IGP Metric-Based Topology (FlexAlgo 0)



TE Metric-Optimized Topology (Flex Algo 128)

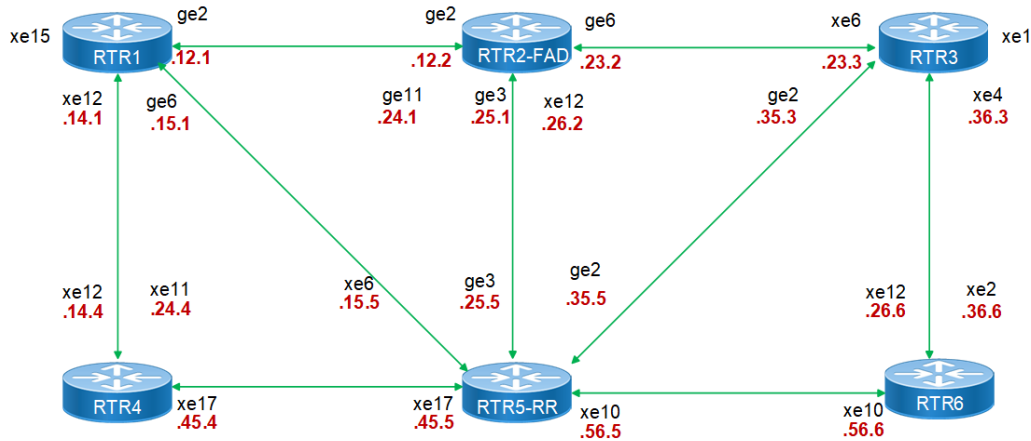
Focuses on Traffic Engineering (TE) metrics to optimize network paths. Considers all links with configured TE metrics, such as bandwidth utilization.

Logical Representation: Includes only links with a specific Explicit Affinity Group (EAG) marked as GREEN. Other links (for example: GREY) are excluded, ensuring that the topology adheres to specific affinity constraints.

Use Case: Ideal for scenarios requiring bandwidth efficiency or load balancing. Used for traffic engineering when path optimization is critical.

Example: Managing high-throughput services like data center interconnections or streaming services. Only GREEN-affinity links are used to meet bandwidth requirements, while other links are excluded.

Figure 9. TE Metric-Optimized Topology (FlexAlgo 128)



Delay Metric-Optimized Topology (Flex Algo 129)

A topology designed to minimize delay metrics across the network. Delay is measured either dynamically or configured statically to ensure reliability and predictability.

Logical Representation: Includes links with EAG BLUE to ensure low-delay paths.

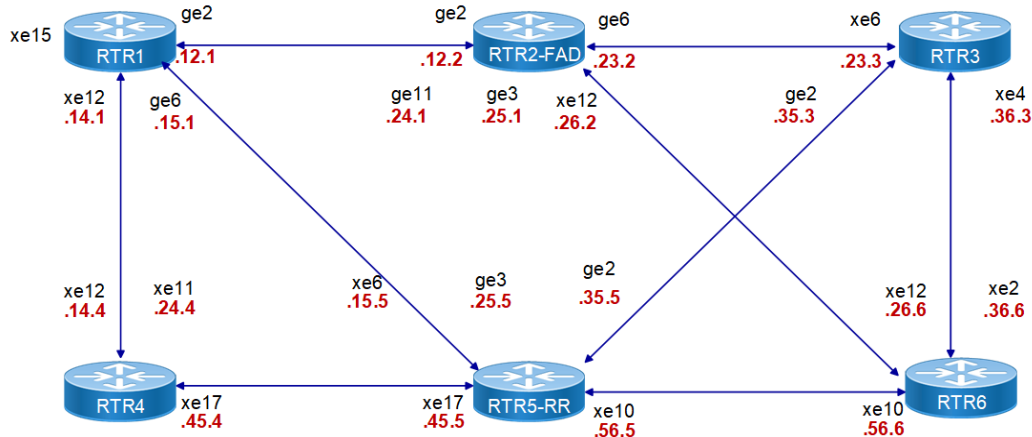
Links not marked BLUE are filtered out to exclude high-latency links.

Use Case: Specifically suited for delay-sensitive traffic such as:

- Voice-over-IP (VoIP)
- Live streaming
- 5G applications requiring minimal latency.

Example: Use BLUE-affinity links exclusively for critical traffic, such as real-time communication or interactive applications.

Figure 10. Delay Metric-Optimized Topology (FlexAlgo 129)



To configure Flex Algo functionality on nodes with ISIS, follow the steps mentioned below:

1. Configure loop-back interfaces.

- Access interface configuration mode for the loopback interface (interface loopback1).
- Assign an IPv4 address to the loopback interface using the IPv4 address command followed by the desired IPv4 address and subnet mask (ip address 25.0.0.1/32).
- Assign appropriate prefix-sid index for the loopback interface (prefix-sid index 1 no-php).
- Assign appropriate prefix-sid index for flex algorithm for the same loopback interface
- Configure IS-IS for IPv4 on the loopback interface using the `ip router isis` command, specifying the IS-IS process ID (ip router isis 1).

```
RTR1(config)#interface loopback2
RTR1(config-if)# ip address 25.0.1.1/32 secondary
RTR1(config-if)# prefix-sid index 1 no-php
RTR1(config-if)# prefix-sid algorithm-num 128 index 1281
RTR1(config-if)# prefix-sid algorithm-num 129 index 1291
RTR1(config-if)# ip router isis 1
RTR1(config-if)# exit
```

2. Configure network interface.

- Access interface configuration mode for the desired network interface (interface ge2 and ge6 and ge12).
- Assign an IPv4 address to the loopback interface using the `ipv4 address` command followed by the desired IPv4 address and subnet mask (ip address 11.0.12.2/24).
- Configure the MTU for the interface (mtu 9216).
- Configure IS-IS for IPv4 on the interface using the `ip router ISIS` command, specifying the IS-IS process ID (ip router isis 1).

```
RTR1(config)#interface ge2
RTR1(config-if)# 11.0.12.2/24
RTR1(config-if)# mtu 9216
RTR1(config-if)# label-switching
RTR1(config-if)# ip router isis 1
RTR1(config-if)#exit
```

3. IS-IS & SR configuration:

- Set IS-IS metrics (default is 10).
- Configure IS-IS for Level 2 with wide metrics.

- c. Enable Segment Routing on all routers:
- d. Configure Node-SID for each router and advertise it:
- e. Configure the New SRGB/SRLB range:

```
RTR1(config-router)# isis 1
RTR1(config-router)# node-sid index 1
RTR1(config)# segment-routing
RTR1(config-sr)# global block 20000 80000
```

Here details on IS-IS parameters:

- Remaining LSP lifetime = 65535 seconds
- LSP refresh (if configurable) = 65000 seconds
- LSP ignore error (ISO:2002 RFC 3719)

4. Flex Algo Configuration:

- a. Enable Flex Algo routing on each router:

```
RTR1(config-router)# capability flex-algo routing
```

- b. Configure Flex Algo 128 and Flex Algo 129 with specific metric types:

- c. Configure Flex Algo 128 to minimize TE metrics and include all links.

```
RTR1(config-router)# flex-algo 128
RTR1(config-isis-fa)# metric-type te-metric
RTR1(config-isis-fa)# exit-flex-algo
```

- d. Configure Flex Algo 129 to optimize for minimizing delay metrics to ensure predictability and includes all links.

```
RTR1(config-router)# flex-algo 129
RTR1(config-isis-fa)# metric-type link-delay
RTR1(config-isis-fa)# exit-flex-algo
```

5. Configure link attributes for Flex Algo.

- a. Assign admin-group and extended admin-group attributes:

- Admin-Group Red: Assigned to bit position 1.
- Extended Admin-Group Green: Assigned to bit position 32
- Extended Admin-Group Blue: Assigned to bit position 93

```
RTR1(config)# admin-group red 1
RTR1(config)# extended-admin-group green 32
RTR1(config)# extended-admin-group blue 93
```

- b. Apply Link Attributes to Interfaces
- c. Access the desired interface configuration mode
- d. Apply the Admin-Group attribute for Flex Algo.
- e. Apply the Extended Admin-Group attributes for Flex Algo:

```
RTR2(config)# interface ge2
RTR2(config-if)# isis admin-group flex-algo red
RTR2(config-if)# isis extended-admin-group flex-algo green
RTR2(config-if)# isis extended-admin-group flex-algo blue
RTR2(config-if)# exit
```

6. Define Flex-Algo advertisement.

- a. Configure R2 to advertise Flex Algo 128 with a priority of 131:

```
RTR2(config-router)#flex-algo 128
RTR2(config-isis-fa)#priority 131
RTR2(config-isis-fa)#affinity-eag-include-any green
RTR2(config-isis-fa)#exit-flex-algo
```

- b. Configure R5 to serve as the backup node, and advertise the Flex-Algo with a priority of 130.
- c. Configure R2 to advertise Flex Algo 129 with a priority of 131:

```
RTR2(config-router)#flex-algo 129
RTR2(config-isis-fa)#priority 131
RTR2(config-isis-fa)#affinity-eag-include-all blue
RTR2(config-isis-fa)#exit-flex-algo
```

Configuration Snapshot

RTR1

RTR1 Configuration Snapshot

```
qos enable
!
hostname RTR1
!
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
!
router-id 25.0.1.1
!
segment-routing
  global block 20000 80000
!
interface ge2
  load-interval 30
  ip address 11.0.12.1/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface ge6
  load-interval 30
  ip address 11.0.15.1/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface loopback1
  ip address 25.0.0.1/32 secondary
  ip router isis 1
!
```

```
interface loopback2
 ip address 25.0.1.1/32 secondary
 prefix-sid index 1 no-php
 prefix-sid algorithm-num 128 index 1281
 prefix-sid algorithm-num 129 index 1291
 ip router isis 1
!
interface xel2
 load-interval 30
 ip address 11.0.14.1/24
 mtu 9216
 label-switching
 isis network point-to-point
 ip router isis 1
 isis te-metric flex-algo ipv4 10
 isis te-minimum-delay flex-algo 10
 isis te-maximum-delay flex-algo 20
 isis admin-group flex-algo red
 isis admin-group flex-algo anomaly red
 isis extended-admin-group flex-algo green
 isis extended-admin-group flex-algo blue
!
router isis 1
 is-type level-2-only
 ignore-lsp-errors
 capability flex-algo routing
 flex-algo 129
  metric-type link-delay
 exit-flex-algo
!
 flex-algo 128
  metric-type te-metric
 exit-flex-algo
!
 lsp-gen-interval 1
 max-lsp-lifetime 65535
 spf-interval-exp 50 5000
 metric-style wide
 mpls traffic-eng router-id 25.0.1.1
 mpls traffic-eng level-2
 dynamic-hostname
 set-overload-bit on-startup wait-for-bgp
 bfd all-interfaces
 net 49.0000.0100.0000.1011.00
 isis segment-routing global block 20000 80000
 segment-routing mpls
!
router bgp 65010
 neighbor 25.0.0.5 remote-as 65010
 neighbor 25.0.0.5 update-source loopback1
 neighbor 25.0.1.5 remote-as 65010
 neighbor 25.0.1.5 update-source loopback2
!
 address-family ipv4 unicast
 neighbor 25.0.0.5 activate
 exit-address-family
!
 address-family vpnv4 unicast
 neighbor 25.0.1.5 activate
 exit-address-family
!
exit
!
```

RTR2-FAD

RTR2-FAD Configuration Snapshot

```
hardware-profile filter twamp-ipv4 enable
qos enable
!
hostname RTR2
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
!
router-id 25.0.1.2
!
segment-routing
  global block 20000 80000
!
interface ge2
  load-interval 30
  ip address 11.0.12.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface ge3
  load-interval 30
  ip address 11.0.25.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
!
interface ge6
  load-interval 30
  ip address 11.0.23.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface ge11
  load-interval 30
  ip address 11.0.24.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
!
interface loopback1
  ip address 25.0.0.2/32 secondary
```

```
ip router isis 1
!
interface loopback2
ip address 25.0.1.2/32 secondary
prefix-sid index 2 no-php
prefix-sid algorithm-num 128 index 1282
prefix-sid algorithm-num 129 index 1292
ip router isis 1
!
interface xel2
load-interval 30
ip address 11.0.26.2/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
isis extended-admin-group flex-algo blue
!
router isis 1
is-type level-2-only
ignore-lsp-errors
capability flex-algo routing
flex-algo 128
metric-type te-metric
priority 131
affinity-eag-include-any green
exit-flex-algo
!
flex-algo 129
metric-type link-delay
priority 131
affinity-eag-include-all blue
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.2
mpls traffic-eng level-2
dynamic-hostname
set-overload-bit on-startup wait-for-bgp
bfd all-interfaces
net 49.0000.0100.0000.1022.00
redistribute isis level-2 into level-1
isis segment-routing global block 20000 80000
segment-routing mpls
```

RTR3

RTR3 Configuration Snapshot

```
qos enable
!
hostname RTR3
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
!
router-id 25.0.1.3
!
```

```
segment-routing
  global block 20000 80000
!
interface ge2
  load-interval 30
  ip address 11.0.35.3/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface loopback1
  ip address 25.0.0.3/32 secondary
  ip router isis 1
!
interface loopback2
  ip address 25.0.1.3/32 secondary
  prefix-sid index 3 no-php
  prefix-sid algorithm-num 128 index 1283
  prefix-sid algorithm-num 129 index 1293
  ip router isis 1
!
interface xe4
  load-interval 30
  ip address 11.0.36.3/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe6
  speed 1g
  load-interval 30
  ip address 11.0.23.3/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
router isis 1
  is-type level-2-only
  ignore-lsp-errors
  capability flex-algo routing
  flex-algo 129
  metric-type link-delay
  exit-flex-algo
!
```

```
flex-algo 128
  metric-type te-metric
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.3
mpls traffic-eng level-2
dynamic-hostname
set-overload-bit on-startup wait-for-bgp
bfd all-interfaces
net 49.0000.0100.0000.1033.00
isis segment-routing global block 20000 80000
segment-routing mpls
!
router bgp 65010
  neighbor 25.0.0.5 remote-as 65010
  neighbor 25.0.0.5 update-source loopback1
  neighbor 25.0.1.5 remote-as 65010
  neighbor 25.0.1.5 update-source loopback2
  !
  address-family ipv4 unicast
  neighbor 25.0.0.5 activate
  exit-address-family
  !
  address-family vpnv4 unicast
  neighbor 25.0.1.5 activate
  exit-address-family
  !
exit
```

RTR4

RTR4 Configuration Snapshot

```
qos enable
!
hostname RTR4
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
!
router-id 25.0.1.4
!
segment-routing
  global block 20000 80000
!
interface loopback1
  ip address 25.0.0.4/32 secondary
  ip router isis 1
!
interface loopback2
  ip address 25.0.1.4/32 secondary
  prefix-sid index 4 no-php
  prefix-sid algorithm-num 128 index 1284
  prefix-sid algorithm-num 129 index 1294
  ip router isis 1
!
interface xell
  speed 1g
  load-interval 30
  ip address 11.0.24.4/24
  mtu 9216
  label-switching
```



```
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
!
interface xel2
load-interval 30
ip address 11.0.14.4/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
interface xel7
load-interval 30
ip address 11.0.45.4/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
router isis 1
is-type level-2-only
ignore-lsp-errors
capability flex-algo routing
flex-algo 128
metric-type te-metric
exit-flex-algo
!
flex-algo 129
metric-type link-delay
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.4
mpls traffic-eng level-2
dynamic-hostname
set-overload-bit on-startup wait-for-bgp
bfd all-interfaces
net 49.0000.0100.0000.1044.00
isis segment-routing global block 20000 80000
segment-routing mpls
```

RTR5

RTR5 Configuration Snapshot

```
qos enable
!
hostname RTR5
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
router-id 25.0.1.5
!
segment-routing
  global block 20000 80000
!
interface ge2
  load-interval 30
  ip address 11.0.35.5/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface ge3
  load-interval 30
  ip address 11.0.25.5/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
!
interface loopback1
  ip address 25.0.0.5/32 secondary
  ip router isis 1
!
interface loopback2
  ip address 25.0.1.5/32 secondary
  prefix-sid index 5 no-php
  prefix-sid algorithm-num 128 index 1285
  prefix-sid algorithm-num 129 index 1295
  ip router isis 1
!
interface xe6
  speed 1g
  load-interval 30
  ip address 11.0.15.5/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe10
  load-interval 30
  ip address 11.0.56.5/24
```

```
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
interface xe17
load-interval 30
ip address 11.0.45.5/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
router isis 1
is-type level-2-only
ignore-lsp-errors
capability flex-algo routing
flex-algo 128
  metric-type te-metric
  priority 130
exit-flex-algo
!
flex-algo 129
  metric-type link-delay
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.5
mpls traffic-eng level-2
dynamic-hostname
set-overload-bit on-startup wait-for-bgp
bfd all-interfaces
net 49.0000.0100.0000.1055.00
redistribute isis level-2 into level-1
isis segment-routing global block 20000 80000
segment-routing mpls
!
router bgp 65010
neighbor 25.0.0.1 remote-as 65010
neighbor 25.0.0.1 update-source loopback1
neighbor 25.0.0.3 remote-as 65010
neighbor 25.0.0.3 update-source loopback1
neighbor 25.0.1.1 remote-as 65010
neighbor 25.0.1.1 update-source loopback2
neighbor 25.0.1.3 remote-as 65010
neighbor 25.0.1.3 update-source loopback2
!
address-family ipv4 unicast neighbor 25.0.0.1 activate
neighbor 25.0.1.1 route-reflector-client
neighbor 25.0.0.3 activate
neighbor 25.0.1.3 route-reflector-client
```

```
exit-address-family
!
address-family vpnv4 unicast neighbor 25.0.1.1 activate
neighbor 25.0.1.1 route-reflector-client
neighbor 25.0.1.3 activate
neighbor 25.0.1.3 route-reflector-client
exit-address-family
```

RTR6

RTR6 Configuration Snapshot

```
qos enable
!
hostname RTR6
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
router-id 25.0.1.6
!
segment-routing
  global block 20000 80000
!
interface loopback1
  ip address 25.0.0.6/32 secondary
  ip router isis 1
!
interface loopback2
  ip address 25.0.1.6/32 secondary
  prefix-sid index 6 no-php
  prefix-sid algorithm-num 128 index 1286
  prefix-sid algorithm-num 129 index 1296
  ip router isis 1
!
interface xe2
  load-interval 30
  ip address 11.0.36.6/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe10
  load-interval 30
  ip address 11.0.56.6/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 10
  isis te-maximum-delay flex-algo 20
  isis admin-group flex-algo red
  isis admin-group flex-algo anomaly red
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe12
  load-interval 30
```

```
ip address 11.0.26.6/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
isis extended-admin-group flex-algo blue
!
router isis 1
is-type level-2-only
ignore-lsp-errors
capability flex-algo routing
flex-algo 128
  metric-type te-metric
exit-flex-algo
!
flex-algo 129
  metric-type link-delay
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.6
mpls traffic-eng level-2
dynamic-hostname
set-overload-bit on-startup wait-for-bgp
bfd all-interfaces
net 49.0000.0100.0000.1066.00
isis segment-routing global block 20000 80000
segment-routing mpls
```

TWAMP Configurations

RTR1

The following are the step-by-step configurations on the RTR1.

```
hardware-profile filter twamp-ipv4 enable
!
delay-profile interfaces
  mode two-way
  burst-interval 1000
  burst-count 1
  interval 30
  advertisement periodic threshold 10
  advertisement periodic minimum-change 1000
  advertisement accelerated
  advertisement accelerated threshold 20
  advertisement accelerated minimum-change 2000
!
twamp-light reflector
  reflector-admin-state enable
  reflector-name RTR1-RTR2 reflector-ip ipv4 11.0.12.1 reflector-port 1025
!
twamp-light control
  control-admin-state enable
!
```

```
interface ge2
  delay-measurement dynamic twamp reflector-ip 11.0.12.2 reflector-port 1026 sender-ip 11.0.12.1
  loss-measurement dynamic
```

RTR2-FADs

The following are the step-by-step configurations on the RTR2-FADs.

```
hardware-profile filter twamp-ipv4 enable
!
delay-profile interfaces
  mode two-way
  burst-interval 1000
  burst-count 1
  interval 30
  advertisement periodic threshold 10
  advertisement periodic minimum-change 1000
  advertisement accelerated
  advertisement accelerated threshold 20
  advertisement accelerated minimum-change 2000
!
twamp-light reflector
  reflector-admin-state enable
  reflector-name RTR1-RTR2 reflector-ip ipv4 11.0.12.2 reflector-port 1026
!
twamp-light control
  control-admin-state enable
!
interface ge2
  delay-measurement dynamic twamp reflector-ip 11.0.12.1 reflector-port 1025 sender-ip 11.0.12.2
  loss-measurement dynamic
```

Validation

RTR1

Verify that IS-IS adjacencies are established with the expected neighbors and are operating within the Flex-Algo topology.

```
RTR1#show clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 3
Total number of adjacencies: 3
Tag 1: VRF : default
System Id      Interface  SNPA                State Holdtime  Type Protocol
RTR2           ge2       e8c5.7ad4.7205      Up    24         L2   IS-IS
RTR5           ge6       e8c5.7a90.e1c8      Up    24         L2   IS-IS
RTR4           xe12      5c07.5828.af60      Up    24         L2   IS-IS
RTR1#sh isis topology

Tag 1: VRF : default
IS-IS paths to level-2 routers
System Id      Metric  Next-Hop            Interface  SNPA
RTR1           --
RTR2           10      RTR2                ge2        e8c5.7ad4.7205
RTR3           20      RTR2                ge2        e8c5.7ad4.7205
              RTR5                ge6        e8c5.7a90.e1c8
RTR4           10      RTR4                xe12       5c07.5828.af60
RTR5           10      RTR5                ge6        e8c5.7a90.e1c8
RTR6           20      RTR2                ge2        e8c5.7ad4.7205
```

```

RTR5          ge6          e8c5.7a90.e1c8
RTR1#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 1:  VRF : default
Total number of routes: 23


```

	Destination	Metric	Next-Hop	Interface	Tag
C	11.0.12.0/24	10	--	ge2	0
C	11.0.14.0/24	10	--	xe12	0
C	11.0.15.0/24	10	--	ge6	0
L2	11.0.23.0/24	20	11.0.12.2	ge2	0
L2	11.0.24.0/24	20	11.0.14.4	xe12	0
			11.0.12.2	ge2	0
L2	11.0.25.0/24	20	11.0.12.2	ge2	0
			11.0.15.5	ge6	0
L2	11.0.26.0/24	20	11.0.12.2	ge2	0
L2	11.0.35.0/24	20	11.0.15.5	ge6	0
L2	11.0.36.0/24	30	11.0.12.2	ge2	0
			11.0.15.5	ge6	0
L2	11.0.45.0/24	20	11.0.14.4	xe12	0
			11.0.15.5	ge6	0
L2	11.0.56.0/24	20	11.0.15.5	ge6	0
C	25.0.0.1/32	10	--	loopback1	0
L2	25.0.0.2/32	20	11.0.12.2	ge2	0
L2	25.0.0.3/32	30	11.0.12.2	ge2	0
			11.0.15.5	ge6	0
L2	25.0.0.4/32	20	11.0.14.4	xe12	0
L2	25.0.0.5/32	20	11.0.15.5	ge6	0
L2	25.0.0.6/32	30	11.0.12.2	ge2	0
			11.0.15.5	ge6	0
C	25.0.1.1/32	10	--	loopback2	0
L2	25.0.1.2/32	20	11.0.12.2	ge2	0
L2	25.0.1.3/32	30	11.0.12.2	ge2	0
			11.0.15.5	ge6	0
L2	25.0.1.4/32	20	11.0.14.4	xe12	0
L2	25.0.1.5/32	20	11.0.15.5	ge6	0
L2	25.0.1.6/32	30	11.0.12.2	ge2	0
			11.0.15.5	ge6	0

Verify that the route for 25.0.1.3/32 is installed with the expected next-hop and metric, adhering to the Flex-Algo path constraints.

```

RTR1#sh ip route 25.0.1.3/32
VRF: Default, Routing entry for 25.0.1.3/32
  Known via "isis", distance 115, metric 30, External Route Tag: 0, installed 00:38:27, best
  Last update 00:38:27 ago
    * 11.0.15.5, via ge6
    * 11.0.12.2, via ge2

RTR1#
RTR1#show ip isis route prefix 25.0.1.3/32 detail

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 1: VRF : default

```

Hop	Destination	Interface	Metric	Tag	ILM-ID	FTN-ID	In-Label	Next-	Out-Label
L2	25.0.1.3/32		30		15	9	20003	11.0.12.2	ge2
	0	20003							
								11.0.15.5	ge6
	0	20003							

```
Src: 0100.0000.1033 Ifindex 10015
Src: 0100.0000.1033 Ifindex 10003
```

Verify that IS-IS has SR enabled and supports the expected Flex-Algo capabilities, including SR-MPLS and algorithm-specific constraints.

```
RTR1#show isis segment-routing capability

Tag 1 Segment-Routing:
-----
Advertisement Router Capability :25.0.1.1
Algorithm0                     :0
Algorithm1                     :129
Algorithm2                     :128
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :20000 - 80000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :25.0.1.2
Algorithm0                     :0
Algorithm1                     :128
Algorithm2                     :129
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :20000 - 80000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :25.0.1.3
Algorithm0                     :0
Algorithm1                     :129
Algorithm2                     :128
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :20000 - 80000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :25.0.1.4
Algorithm0                     :0
Algorithm1                     :128
Algorithm2                     :129
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :10
SID Range List Count           :1
SID's Range                    :20000 - 80000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :25.0.1.5
Algorithm0                     :0
Algorithm1                     :128
Algorithm2                     :129
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :6
SID Range List Count           :1
```



```

SID's Range                :20000 - 80000
Total SID's Supported (SRLB) :0
SRLB Range List Count      :0
-----
Advertisement Router Capability :25.0.1.6
Algorithm0                  :0
Algorithm1                  :128
Algorithm2                  :129
SRMS Preference             :0
Total SID'S Supported       :60001
SR ERLD                     :10
SID Range List Count        :1
SID's Range                 :20000 - 80000
Total SID's Supported (SRLB) :0
SRLB Range List Count      :0

```

Verify ISIS segment-routing mapping-table ipv4 active

```

RTR1#show isis segment-routing mapping-table ipv4 active
Tag 1 Segment-Routing:
Conflict Resolution Policy: Quarantine

```

Prefix	Range	Flags	Algo/SID-Index/Prefix-Flag List
25.0.1.1/32	1		Algo:0 SID:1 PF:60 Algo:128 SID:1281 PF:40 Algo:129 SID:1291 PF:40
25.0.1.2/32	1		Algo:0 SID:2 PF:60 Algo:128 SID:1282 PF:40 Algo:129 SID:1292 PF:40
25.0.1.3/32	1		Algo:0 SID:3 PF:60 Algo:128 SID:1283 PF:40 Algo:129 SID:1293 PF:40
25.0.1.4/32	1		Algo:0 SID:4 PF:60 Algo:128 SID:1284 PF:40 Algo:129 SID:1294 PF:40
25.0.1.5/32	1		Algo:0 SID:5 PF:60 Algo:128 SID:1285 PF:40 Algo:129 SID:1295 PF:40
25.0.1.6/32	1		Algo:0 SID:6 PF:60 Algo:128 SID:1286 PF:40 Algo:129 SID:1296 PF:40

MPLS Validation on RTR1

```

RTR1#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, (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: Disabled

Code	FEC	Nexthop	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC		Algo-Num	UpTime				
i>	25.0.1.2/32	1	8	-	-	-	-	-
	-	128	00:40:11					
	11.0.12.2	-	1	0	Yes	3	ge2	No
i>	25.0.1.2/32	3	8	-	-	-	-	-
	-	129	00:40:11					
	11.0.12.2	-	1	0	Yes	3	ge2	No
i>	25.0.1.2/32	5	14	-	-	-	-	-
	-	0	00:40:11					
	11.0.12.2	-	13	0	Yes	20002	ge2	No
i>	25.0.1.3/32	7	20	-	-	-	-	-
	-	128	00:40:11					

```

11.0.12.2      -      -      29      0      Yes  21283      ge2      No
11.0.15.5      -      -      19      0      Yes  21283      ge6      No
i> 25.0.1.3/32      11      38      -      -      -      -      -
-      129      00:40:11
37      0
11.0.12.2      -      -      27      -      -      -      -
i> 25.0.1.3/32      9      27      -      -      -      -      -
-      0      00:40:11
32      0
11.0.12.2      -      -      26      0      Yes  20003      ge2      No
11.0.15.5      -      -      26      0      Yes  20003      ge6      No
i> 25.0.1.4/32      2      11      -      -      -      -      -
-      128      00:40:11
22      0
11.0.14.4      -      -      11      -      -      -      -
i> 25.0.1.4/32      4      11      -      -      -      -      -
-      129      00:40:11
22      0
11.0.14.4      -      -      17      -      -      -      -
i> 25.0.1.4/32      6      17      -      -      -      -      -
-      0      00:40:11
16      0
11.0.14.4      -      -      24      -      -      -      -
i> 25.0.1.5/32      8      24      -      -      -      -      -
-      128      00:40:11
9      0
11.0.15.5      -      -      24      -      -      -      -
i> 25.0.1.5/32      12      24      -      -      -      -      -
-      129      00:40:11
9      0
11.0.15.5      -      -      33      -      -      -      -
i> 25.0.1.5/32      10      33      -      -      -      -      -
-      0      00:40:11
31      0
11.0.15.5      -      -      41      -      -      -      -
i> 25.0.1.6/32      13      41      -      -      -      -      -
-      129      00:40:11
40      0
11.0.12.2      -      -      44      -      -      -      -
i> 25.0.1.6/32      14      44      -      -      -      -      -
-      128      00:40:11
43      0
11.0.15.5      -      -      47      -      -      -      -
i> 25.0.1.6/32      15      47      -      -      -      -      -
-      0      00:40:11
35      0
11.0.12.2      -      -      46      0      Yes  20006      ge2      No
11.0.15.5      -      -      46      0      Yes  20006      ge6      No
11.0.15.5      -      -      -      -      -      -      -
RTR1#show mpls forwarding-table 25.0.1.3/32
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: Disabled
Code   FEC           FTN-ID   Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC           Nexthop   Algo-Num  UpTime
i> 25.0.1.3/32      7        20        -          -          -      -      -
-      128      00:40:42
29      0
11.0.12.2      -      -      19      0      Yes  21283      ge2      No
11.0.15.5      -      -      19      0      Yes  21283      ge6      No
i> 25.0.1.3/32      11      38      -      -      -      -      -
-      129      00:40:42

```

11.0.12.2	-	-	37	0	Yes	21293	ge2	No
i> 25.0.1.3/32	9	27	-	-	-	-	-	-
-	0	00:40:42	32	0	Yes	20003	ge2	No
11.0.12.2	-	-	26	0	Yes	20003	ge6	No
11.0.15.5	-	-						

Verify that the FTN entry correctly maps the prefix 25.0.1.3/32 to the expected SR Label and next-hop based on the Flex-Algo policy.

```
RTR1#show mpls ftn-table 25.0.1.3/32
Primary FTN entry with FEC: 25.0.1.3/32, id: 7, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:40:48, UpTime: 00:40:48, LastUpdate: N/A
  Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm Number:128
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 29 refcount: 1
  Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 29, owner: ISIS-SR-FA, Stale: NO, refcount: 4, out intf: ge2, out
  label: 21283
  Nexthop addr: 11.0.12.2          cross connect ix: 10, op code: Push

  Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 19 refcount: 1
  Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 19, owner: ISIS-SR-FA, Stale: NO, refcount: 2, out intf: ge6, out
  label: 21283
  Nexthop addr: 11.0.15.5          cross connect ix: 10, op code: Push

Primary FTN entry with FEC: 25.0.1.3/32, id: 11, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:40:48, UpTime: 00:40:48, LastUpdate: N/A
  Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm Number:129
  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: 37 refcount: 1
  Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 37, owner: ISIS-SR-FA, Stale: NO, refcount: 2, out intf: ge2, out
  label: 21293
  Nexthop addr: 11.0.12.2          cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 25.0.1.3/32, id: 9, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:40:48, UpTime: 00:40:48, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm Number:0
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 32 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 32, owner: ISIS-SR, Stale: NO, refcount: 4, out intf: ge2, out
  label: 20003
  Nexthop addr: 11.0.12.2          cross connect ix: 11, op code: Push

  Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 26 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 26, owner: ISIS-SR, Stale: NO, refcount: 2, out intf: ge6, out
  label: 20003
  Nexthop addr: 11.0.15.5          cross connect ix: 11, op code: Push
```

Verify the IS-IS path metrics assigned to each link in the Flex-Algo topology.

```
RTR1#show isis topology algorithm 128

Tag 1: VRF : default
IS-IS paths to level-2 routers
Flex-algo 128
System Id      Metric      Next-Hop      Interface      SNPA
RTR1           --
RTR2           10          RTR2          ge2            e8c5.7ad4.7205
RTR3           20          RTR2          ge2            e8c5.7ad4.7205
               RTR5          ge6            e8c5.7a90.e1c8
RTR4           10          RTR4          xe12           5c07.5828.af60
RTR5           10          RTR5          ge6            e8c5.7a90.e1c8
RTR6           20          RTR5          ge6            e8c5.7a90.e1c8
```

Verify the Flex Algo128 to view its configured parameters.

```
RTR1#show ip isis route algorithm 128

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 1: VRF : default
Total number of routes: 23

      Destination      Metric      Next-Hop      Interface      Tag
C    11.0.12.0/24       10          --           ge2            0
C    11.0.14.0/24       10          --           xe12           0
C    11.0.15.0/24       10          --           ge6            0
L2   11.0.23.0/24       20          11.0.12.2     ge2            0
L2   11.0.24.0/24       20          11.0.14.4     xe12           0
              11.0.12.2     ge2            0
L2   11.0.25.0/24       20          11.0.12.2     ge2            0
              11.0.15.5     ge6            0
L2   11.0.26.0/24       20          11.0.12.2     ge2            0
L2   11.0.35.0/24       20          11.0.15.5     ge6            0
L2   11.0.36.0/24       30          11.0.12.2     ge2            0
              11.0.15.5     ge6            0
L2   11.0.45.0/24       20          11.0.14.4     xe12           0
              11.0.15.5     ge6            0
L2   11.0.56.0/24       20          11.0.15.5     ge6            0
C    25.0.0.1/32        10          --           loopback1      0
L2   25.0.0.2/32        20          11.0.12.2     ge2            0
L2   25.0.0.3/32        30          11.0.12.2     ge2            0
              11.0.15.5     ge6            0
L2   25.0.0.4/32        20          11.0.14.4     xe12           0
L2   25.0.0.5/32        20          11.0.15.5     ge6            0
L2   25.0.0.6/32        30          11.0.15.5     ge6            0
C    25.0.1.1/32        10          --           loopback2      0
L2   25.0.1.2/32        20          11.0.12.2     ge2            0
L2   25.0.1.3/32        30          11.0.12.2     ge2            0
              11.0.15.5     ge6            0
L2   25.0.1.4/32        20          11.0.14.4     xe12           0
L2   25.0.1.5/32        20          11.0.15.5     ge6            0
L2   25.0.1.6/32        30          11.0.15.5     ge6            0

RTR1#
RTR1#show ip isis route prefix 25.0.1.3/32 algorithm 128

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 1: VRF : default
      Destination      Metric      Next-Hop      Interface      Tag
L2   25.0.1.3/32       30          11.0.12.2     ge2            0
```

11.0.15.5

ge6

0

Verify that the configured Flex-Algo parameters, constraints, and metrics are correctly applied and operational within the IS-IS domain.

```
RTR1#show isis flex-algo control
ISIS Instance : 1
Num of times NSM disconnects received: 0
Num of times NSM Admin Group mapping received: 2
Num of times NSM Extended Admin Group mapping received: 3
Flex-Algo ASLA advertising: On
Flex-Algo strict ASLA usage: Off
Flex-Algo Routing Capability: Yes
Flex-Algo Readvertise Capability: No
Flex-Algo CSPF Capability: Yes
Flex-Algo Adjacency-SID Capability: No
Flex-Algo Strict Adjacency-SID Capability: No
Flex-Algo Backup Adjacency-SID Capability: No
Flex-Algo QoS-Policy Capability: No
Flex-Algo BGP-LS Capability: No
RTR1#
RTR1#show isis flex-algo 128 status winner detail
ISIS Instance : 1
Router-ID : 25.0.1.2, System-ID : 0100.0000.1022
Algorithm Number : 128
Metric Type : te-metric
Calculation Type : spf
Priority : 131 (Winner)
Prefix Metric Flag : No
Fwd-Exclude-Any-AG Mask : None
Fwd-Include-Any-AG Mask : None
Fwd-Include-All-AG Mask : None
Rev-Exclude-Any-AG Mask : None
Rev-Include-Any-AG Mask : None
Rev-Include-All-AG Mask : None
Fwd-Exclude-Any-EAG Mask : NULL
Fwd-Include-Any-EAG Mask :
(32)
Fwd-Include-All-EAG Mask : NULL
Rev-Exclude-Any-EAG Mask : NULL
Rev-Include-Any-EAG Mask : NULL
Rev-Include-All-EAG Mask : NULL
Exclude SRLG-ID List : NULL
Exclude Minimum Bandwidth : 0
Exclude Maximum Delay : 0
Intf-Group Mode Total B/W Calculate : No
Reference Bandwidth : 0
Granularity Bandwidth : 0
```

Verify that Flex-Algo 128 is enabled, correctly configured, and active with the expected user-defined constraints and parameters.

```
RTR1#show isis flex-algo 128 status usercfg summary
ISIS Instance : 1
Algorithm Number : 128
Metric Type : te-metric
Calculation Type : spf
Priority : 5
Prefix Metric Flag: No
RTR1#
RTR1#show isis flex-algo 128 status election summary
ISIS Instance : 1
Router-ID : 25.0.1.2, System-ID : 0100.0000.1022
Algorithm Number : 128
```

```

Metric Type      : te-metric
Calculation Type : spf
Priority         : 131 (Winner)
Prefix Metric Flag : No

Router-ID : 25.0.1.5, System-ID : 0100.0000.1055
Algorithm Number : 128
Metric Type      : te-metric
Calculation Type : spf
Priority         : 130
Prefix Metric Flag : No

Router-ID : 25.0.1.6, System-ID : 0100.0000.1066
Algorithm Number : 128
Metric Type      : te-metric
Calculation Type : spf
Priority         : 5
Prefix Metric Flag : No

Router-ID : 25.0.1.4, System-ID : 0100.0000.1044
Algorithm Number : 128
Metric Type      : te-metric
Calculation Type : spf
Priority         : 5
Prefix Metric Flag : No

Router-ID : 25.0.1.3, System-ID : 0100.0000.1033
Algorithm Number : 128
Metric Type      : te-metric
Calculation Type : spf
Priority         : 5
Prefix Metric Flag : No

Router-ID : 25.0.1.1, System-ID : 0100.0000.1011
Algorithm Number : 128
Metric Type      : te-metric
Calculation Type : spf
Priority         : 5
Prefix Metric Flag : No
RTR1#show isis flex-algo 128 status winner summary
ISIS Instance : 1
Router-ID : 25.0.1.2, System-ID : 0100.0000.1022
Algorithm Number : 128
Metric Type      : te-metric
Calculation Type : spf
Priority         : 131 (Winner)
Prefix Metric Flag : No

RTR1#show mpls forwarding-table algorithm 128
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: Disabled

```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nextthop	Algo-Num	UpTime			
i>	25.0.1.2/32	1	8	-	-	-	-
	-	128	01:19:19				
			1	0	Yes	3	ge2
	11.0.12.2	-	-				No
i>	25.0.1.3/32	7	20	-	-	-	-
	-	128	01:19:19				
			29	0	Yes	21283	ge2
	11.0.12.2	-	-				No
			19	0	Yes	21283	ge6
	11.0.15.5	-	-				No

```

i> 25.0.1.4/32      2      11      -      -      -      -      -
    -              128      01:19:19      22      0      Yes      3      xe12      No
    11.0.14.4      -      -
i> 25.0.1.5/32      8      24      -      -      -      -      -
    -              128      01:19:19      9      0      Yes      3      ge6      No
    11.0.15.5      -      -
i> 25.0.1.6/32      14     44      -      -      -      -      -
    -              128      01:19:19      43     0      Yes     21286     ge6      No
    11.0.15.5      -      -

RTR1#
RTR1#show mpls ftn-table algorithm 128
  Primary FTN entry with FEC: 25.0.1.2/32, id: 1, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 01:19:35, UpTime: 01:19:35, LastUpdate: N/A
    Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm Number:128
    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: 1 refcount: 1
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 1, owner: N/A, Stale: NO, refcount: 9, out intf: ge2, out label: 3
    Nexthop addr: 11.0.12.2      cross connect ix: 2, op code: Push

  Primary FTN entry with FEC: 25.0.1.3/32, id: 7, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 01:19:35, UpTime: 01:19:35, LastUpdate: N/A
    Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm Number:128
    Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
    Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 29 refcount: 1
    Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 29, owner: ISIS-SR-FA, Stale: NO, refcount: 4, out intf: ge2, out
    label: 21283
    Nexthop addr: 11.0.12.2      cross connect ix: 10, op code: Push

    Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 19 refcount: 1
    Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 19, owner: ISIS-SR-FA, Stale: NO, refcount: 2, out intf: ge6, out
    label: 21283
    Nexthop addr: 11.0.15.5      cross connect ix: 10, op code: Push

  Primary FTN entry with FEC: 25.0.1.4/32, id: 2, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 01:19:35, UpTime: 01:19:35, LastUpdate: N/A
    Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm Number:128
    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: 22 refcount: 1
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 22, owner: N/A, Stale: NO, refcount: 9, out intf: xe12, out label: 3
    Nexthop addr: 11.0.14.4      cross connect ix: 6, op code: Push

  Primary FTN entry with FEC: 25.0.1.5/32, id: 8, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 01:19:35, UpTime: 01:19:35, LastUpdate: N/A
    Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm Number:128
    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: 9 refcount: 1
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 9, owner: N/A, Stale: NO, refcount: 9, out intf: ge6, out label: 3

```

```

    Nexthop addr: 11.0.15.5          cross connect ix: 4, op code: Push

    Primary FTN entry with FEC: 25.0.1.6/32, id: 14, row status: Active, Tunnel-Policy: N/A, State:
    Installed
    CreateTime: 01:19:35, UpTime: 01:19:35, LastUpdate: N/A
    Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm Number:128
    Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
    Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 43 refcount: 1
    Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 43, owner: ISIS-SR-FA, Stale: NO, refcount: 2, out intf: ge6, out
    label: 21286
    Nexthop addr: 11.0.15.5
    cross connect ix: 13, op code: Push

```

Implementation Examples

Traffic Optimization in Multi-Service Networks: Using flex algo bulk data transfers can prioritize cost-effective paths over low-latency ones.

Dynamic Resource Allocation in 5G Networks: In a 5G network, diverse applications such as real-time communication, IoT devices, and large data transfers require unique routing and resource allocation to meet their performance needs. Algo allows tailored routing paths for different applications (for example: low-latency routes for real-time communication, energy-efficient paths for IoT devices). It ensures optimal resource utilization while meeting the performance requirements of various 5G use cases.

Content Delivery Networks (CDNs): A CDN provider delivers content to end-users from multiple distributed servers. Flex Algo optimizes traffic flow to ensure the shortest delivery times based on user location and server availability.

CLI Commands

The `isis flex-algo` introduces the following configuration commands.

- [advertise \(page 117\)](#)
- [affinity-ag-exclude-any \(page 124\)](#)
- [affinity-ag-include-any \(page 125\)](#)
- [affinity-ag-include-all \(page 125\)](#)
- [affinity-ag-reverse-exclude-any \(page 126\)](#)
- [affinity-ag-reverse-include-any \(page 127\)](#)
- [affinity-ag-reverse-include-all \(page 126\)](#)
- [affinity-eag-exclude-any \(page 127\)](#)
- [affinity-eag-include-any \(page 129\)](#)
- [affinity-eag-include-all \(page 128\)](#)
- [affinity-eag-reverse-exclude-any \(page 129\)](#)
- [affinity-eag-reverse-include-any \(page 130\)](#)
- [affinity-eag-reverse-include-all \(page 130\)](#)
- [asla flex-algo \(page 119\)](#)
- [asla all-apps \(page 118\)](#)

- [capability flex-algo \(page 119\)](#)
- [exclude-maximum-delay \(page 123\)](#)
- [extended-admin-group \(page 134\)](#)
- [extended-admin-group flex anomaly \(page 135\)](#)
- [flex-algo \(page 120\)](#)
- [isis admin-group flex-algo \(page 120\)](#)
- [isis admin-group anomaly flex-algo \(page 136\)](#)
- [isis extended-admin-group flex-algo \(page 135\)](#)
- [isis extended-admin-group flex anomaly \(page 136\)](#)
- [isis te-metric flex-algo ipv4 \(page 131\)](#)
- [isis te-minimum-delay \(page 132\)](#)
- [isis te-maximum-delay \(page 132\)](#)
- [isis te-minimum-delay flex-algo \(page 133\)](#)
- [isis te-maximum-delay flex-algo \(page 133\)](#)
- [metric-type \(page 121\)](#)
- [priority \(page 122\)](#)
- [participate \(page 122\)](#)
- [ti-lfa \(page 123\)](#)
- [show isis flex-algo \(page 137\)](#)
- [show isis flex-algo number status \(page 138\)](#)
- [show isis flex-algo all status usercfg \(page 139\)](#)
-
- [show isis extend-admin-groups \(page 141\)](#)
- [show isis flex-algo all status \(page 141\)](#)
- [show isis flex-algo all status usercfg \(page 139\)](#)
-
- [show isis flex-algo all status winner \(page 140\)](#)
- [show isis extend-admin-groups \(page 141\)](#)
- [show isis flex-algo all status \(page 141\)](#)

advertise

Use this command to enable advertisement of the Flexible Algorithm definition.

Use the `no` form of this command to disable advertisement of the Flexible Algorithm definition.

Command Syntax

```
advertise
no advertise
```

Parameters

None

Default

5

Command Mode

ISIS Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)# router isis 1
ocnos(config-router)#flex-algo 128
ocnos(config-isis-fa)#advertise
```

asla all-apps

Use this command to enable or disables the advertisement of Application-Specific Link Attributes (ASLA) link attributes for use by all applications in IS-IS routing path computations.

Use the `no` to disable the advertisement of ASLA link attributes for use by all applications in IS-IS routing path calculations.

Command Syntax

```
asla all-apps (advertise)
no asla all-apps (advertise)
```

Parameters**advertise**

Enables the advertisement of Flexible algorithm specific ASLA link attributes in ISIS routing.

Default

Disabled

Command Mode

ISIS Routing Mode

Applicability

Introduced in OcNOS version 6.6.1.

Example

```
ocnos(config)#router isis 1
ocnos(config-router)#asla all-apps advertise
```

asla flex-algo

Use this command to enable the advertisement of Flexible algorithm specific ASLA link attributes in ISIS routing.

Use the `no` parameter of this command to disable the advertisement of Flexible algorithm specific ASLA link attributes in ISIS routing.

Command Syntax

```
asla flex-algo (advertise|strict)
no asla flex-algo (advertise|strict)
```

Parameters

advertise

Enables the advertisement of Flexible algorithm specific ASLA link attributes in ISIS routing.

strict

Enables the usage of strict ASLA link attributes for Flexible Algorithm specific path calculation in ISIS

Default

Disabled

Command Mode

Segment-routing Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)#router isis 1
ocnos(config-router)#asla flex-algo
ocnos(config-router)#asla flex-algo strict
```

capability flex-algo

Use this command to enable the Flexible Algorithm feature for every ISIS routing instance.

Use the `no` form of this command to disable the Flexible Algorithm feature in NSM

Command Syntax

```
capability flex-algo routing
no capability flex-algo routing
```

Parameters

routing

Enables the Flexible Algorithm feature on a per ISIS routing instance basis

Default

Disabled

Command Mode

Segment-routing Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)#router isis 1
ocnos(config-router)#flex-algo 128
ocnos(config-router)#capability flex-algo routing
```

flex-algo

Use this command to create a new sub-mode `config-isis-fa` under ISIS router configuration mode.

Use the `no` parameter of this command to disable the new sub-mode `config-isis-fa` under ISIS router configuration mode.

Command Syntax

```
flex-algo <128-255>
```

Parameters

<128-255>

Specifies the flexible algorithm number range.

Default

Disabled

Command Mode

ISIS Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)#router isis 1
ocnos(config-router)#flex-algo 128
```

isis admin-group flex-algo

Use this command to assign an admin group to a specific Flex-Algorithm (Flex-Algo) in IS-IS.

Use the `no` form of this command to assign an Admin Group to a specific Flex-Algorithm (Flex-Algo) in IS-IS.

Command Syntax

```
isis admin-group flex-algo <1 - 16777214>
no isis admin-group flex-algo <1 - 16777214>
```

Parameters**<1 - 16777214>**

Specifies the flex-algo ID that will be associated with an admin group.

Default

Disabled

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)#interface eth1
ocnos(config-if)#isis admin-group flex-algo 128
```

metric-type

Use this command to specify the type of metric to be used for path computation in routing protocols, such as IS-IS or Traffic Engineering. This command allows selecting different metric types based on network optimization requirements.

Use the `no` form of this command to enable metric type as `igp-metric`.

Command Syntax

```
metric-type {igp-metric | te-metric | link-delay}
no metric-type {igp-metric | te-metric | link-delay}
```

Parameters**igp-metric**

Specifies the Interior Gateway Protocol (IGP) metric for routing decisions.

te-metric

Specifies the TE default metric.

link-delay

Specifies the minimum number of unidirectional link delay.

Default

IGP

Command Mode

ISIS Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)#router isis 1
ocnos(config-router)#flex-algo 128
ocnos(config-isis-fa)#metric-type te-metric
```

participate

Use this command to enable participation for a Flexible Algorithm.

Use the `no` form of this command to disable participation for a Flexible Algorithm.

Command Syntax

```
participate
no participate
```

Parameters

None

Default

None

Command Mode

ISIS Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)# router isis 1
ocnos(config-router)#flex-algo 128
ocnos(config-isis-fa)#participate
```

priority

Use this command to define the priority value for a specific process, protocol, or routing decision. The priority value determines the precedence of an entity when multiple options exist.

Use the `no` form of this command to reset the priority value to the default value of 5.

Command Syntax

```
priority <1-255>
no priority <1-255>
```

Parameters

<1-255>

Specifies the value of priority for Flexible Algorithm (nor for routing).

Default

5

Command Mode

ISIS Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)#router isis 1
ocnos(config-router)#flex-algo 128
ocnos(config-isis-fa)# priority 200
```

ti-lfa

Use this command to enable TI-LFA based fast rerouting of primary paths associated to a flexible algorithm.

Use the `no` form of this command to disable TI-LFA based fast rerouting of primary paths associated to a flexible algorithm.

Command Syntax

```
ti-lfa
no ti-lfa
```

Parameters

None

Default

None

Command Mode

ISIS Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config)# router isis 1
ocnos(config-router)#flex-algo 128
ocnos(config-isis-fa)# ti-lfa
```

exclude-maximum-delay

Use this command to set the exclude maximum link delay value constraint for a Flexible Algorithm definition.

Use the `no` form of this command to unset the exclude maximum link delay value constraint for a Flexible Algorithm definition.

Command Syntax

```
exclude-maximum-delay <1-16777215>
no exclude-maximum-delay <1-16777215>
```

Parameters**<1-16777215>**

Specifies the maximum delay value in the range.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
ocnos(config-router)#flex-algo 128
ocnos(config-isis-fa)#maximum-delay 300
OcNOS(config-if)# exclude-maximum-delay 100000
```

affinity-ag-exclude-any

Use this command to configure a Exclude any Admin-Group affinity name for the forward direction.

Use the `no` form of this command to disable the exclude maximum link delay value constraint for a Flexible Algorithm definition.

Command Syntax

```
affinity-ag-exclude-any (word)
no affinity-ag-exclude-any (word)
```

Parameters**(word)**

Specifies the EAG affinity name that should be included from path selection.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)# affinity-ag-exclude-any 0x02
```


affinity-ag-include-all

Use this command to configure a include all Admin-Group affinity name for the forward direction.

Use the `no` form of this command to exclude include all Admin-Group affinity name for the forward direction.

Command Syntax

```
affinity-ag-include-all (word)
no affinity-ag-include-all (word)
```

Parameters

(word)

Specifies the EAG affinity name that should be included from path selection.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)# affinity-eag-include-all EAG_LOW_LATENCY
EAG_HIGH_PRIORITY
```

affinity-ag-include-any

Use this command to configure a include any Admin-Group affinity name for the forward direction.

Use the `no` form of this command to exclude the to configure a Include any Admin-Group affinity name for the forward direction.

Command Syntax

```
affinity-ag-include-any word
no affinity-ag-include-any word
```

Parameters

(word)

Specifies the affinity group(s) that must be included in the path.

Default

None

Command Mode

ISIS Flex Algo Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)# affinity-ag-include-any 0x02
```

affinity-ag-reverse-exclude-any

Use this command to configure a exclude any Admin-Group affinity name for the reverse direction.

Use the `no` form of this command to disable a exclude any Admin-Group affinity name for the reverse direction.

Command Syntax

```
affinity-ag-reverse-exclude-any (word)
no affinity-ag-reverse-exclude-any (word)
```

Parameters

(word)

Specifies the name of the Admin-Group affinity to be excluded.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)# affinity-ag-reverse-exclude-any REVERSE_HIGH_LATENCY
```

affinity-ag-reverse-include-all

Use this command to configure an include all Admin-Group affinity name for the reverse direction.

Use the `no` form of this command to exclude all Admin-Group affinity name for the reverse direction.

Command Syntax

```
affinity-ag-reverse-include-all} (Word)
no affinity-ag-reverse-include-all} (Word)
```

Parameters

(Word)

Specifies the Admin-Group affinity name to include all associated links in the reverse direction.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)# affinity-ag-reverse-include-all REVERSE_LOW_LATENCY REVERSE_HIGH_PRIORITY
```

affinity-ag-reverse-include-any

Use this command to configure a include any Admin-Group affinity name for the reverse direction.

Use the `no` form of this command to exclude a include any Admin-Group affinity name for the reverse direction.

Command Syntax

```
affinity-ag-reverse-include-any (Word)
no affinity-ag-reverse-include-any (Word)
```

Parameters**(Word)**

Specifies the name of the Admin-Group affinity to be included for the reverse direction.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)# affinity-ag-reverse-include-any REVERSE_TRUSTED_PATHS
```

affinity-eag-exclude-any

Use this command to configure a exclude any Explicit Affinity Group (EAG) affinity name for the forward direction.

Use the `no` form of this command to disable a exclude any EAG affinity name for the forward direction.

Command Syntax

```
affinity-eag-exclude-any (Word)
no affinity-eag-exclude-any (Word)
```

Parameters

(Word)

Specifies the EAG affinity name that should be excluded from path selection.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)#affinity-eag-exclude-any EAG_UNTRUSTED
```

affinity-eag-include-all

Use this command to configure a include all Explicit Affinity Group (EAG) affinity name for the forward direction.

Use the `no` form of this command to disable a include all EAG affinity name for the forward direction.

Command Syntax

```
affinity-eag-include-all (Word)
no affinity-eag-include-all (Word)
```

Parameters

(Word)

Specifies the EAG affinity name that should be included from path selection.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)#affinity-eag-include-all EAG_LOW_LATENCY EAG_HIGH_PRIORITY
```

affinity-eag-include-any

Use this command to configure a include any Explicit Affinity Group (EAG) affinity name for the forward direction.

Use the `no` form of this command to disable a include any EAG affinity name for the forward direction.

Command Syntax

```
affinity-eag-include-any (Word)
no affinity-eag-include-any (Word)
```

Parameters

(Word)

Specifies the EAG affinity name that should be included from path selection.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)#affinity-eag-include-any EAG_TRUSTED_PATHS
```

affinity-eag-reverse-exclude-any

Use this command to configure a exclude any Explicit Affinity Group (EAG) affinity name for the reverse direction.

Use the `no` form of this command to disable a exclude any EAG affinity name for the reverse direction.

Command Syntax

```
affinity-eag-reverse-exclude-any (Word)
no affinity-eag-reverse-exclude-any (Word)
```

Parameters

(Word)

Specifies the EAG affinity name that should be excluded from reverse direction path computation.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)#affinity-eag-reverse-exclude-any EAG_UNTRUSTED
```

affinity-eag-reverse-include-all

Use this command to configure a include all Explicit Affinity Group (EAG) affinity name for the reverse direction.

Use the `no` form of this command to disable a include all EAG affinity name for the reverse direction.

Command Syntax

```
affinity-eag-reverse-include-all (Word)
no affinity-eag-reverse-include-all (Word)
```

Parameters

(Word)

Specifies the EAG affinity name that should be included all links from reverse direction path computation.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)#affinity-eag-reverse-include-all EAG_LOW_LATENCY EAG_HIGH_PRIORITY
```

affinity-eag-reverse-include-any

Use this command to configure a include any Explicit Affinity Group (EAG) affinity name for the reverse direction.

Use the `no` form of this command to disable a include any EAG affinity name for the reverse direction.

Command Syntax

```
affinity-eag-reverse-include-any (Word)
no affinity-eag-reverse-include-any (Word)
```

Parameters**(Word)**

Specifies the EAG affinity name that should be included from reverse direction path computation.

Default

None

Command Mode

ISIS Flex Algo Router Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# router isis 1
OcNOS(config-router)# flex-algo 128
OcNOS(config-isis-fa)#affinity-eag-reverse-include-any EAG_LOW_LATENCY EAG_HIGH_PRIORITY
```

isis te-metric flex-algo ipv4

Use this command to set the Traffic Engineering (TE) metric on an interface for the Flexible Algorithm application..

Use the `no` form of this command to unset the TE metric on an interface for the Flexible Algorithm application..

Command Syntax

```
isis te-metric flex-algo ipv4 <1-16777214>
no isis te-metric flex-algo ipv4 <1-16777214>
```

Parameters**<1-16777214>**

Flexible Algorithm IPv4 TE metric value.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# interface eth 1
OcNOS(config-if)# isis te-metric flex-algo ipv4 1
```

isis te-maximum-delay

Use this command to configure the Traffic Engineering (TE) maximum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Use the `no` form of this command to disable the TE maximum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Command Syntax

```
isis te-maximum-delay flex-algo <1-16777214>  
no isis te-maximum-delay flex-algo <1-16777214>
```

Parameters

<1-16777214>

Flexible Algorithm TE metric value.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# Interface eth 1  
OcNOS(config-if)# isis te-maximum-delay flex-algo 1
```

isis te-minimum-delay

Use this command to configure the Traffic Engineering (TE) maximum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Use the `no` form of this command to disable the TE maximum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Command Syntax

```
isis te-minimum-delay flex-algo <1-16777214>  
no isis te-minimum-delay flex-algo <1-16777214>
```

Parameters

<1-16777214>

Flexible Algorithm IPv4 TE metric value.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# interface eth 1
OcNOS(config-if)# isis te-minimum-delay flex-algo 1
```

isis te-maximum-delay flex-algo

Use this command to configure the Traffic Engineering (TE) maximum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Use the `no` form of this command to disable the TE maximum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Command Syntax

```
isis te-maximum-delay flex-algo <1-16777214>
no isis te-maximum-delay flex-algo <1-16777214>
```

Parameters

<1-16777214>

Flexible Algorithm IPv4 TE metric value.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# interface eth 1
OcNOS(config-if)# isis te-maximum-delay flex-algo 1
```

isis te-minimum-delay flex-algo

Use this command to configure the Traffic Engineering (TE) minimum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Use the `no` form of this command to disable the TE minimum delay value on a ISIS routing enabled interface for the Flexible Algorithm application.

Command Syntax

```
isis te-minimum-delay flex-algo <1-16777214>  
no isis te-minimum-delay flex-algo <1-16777214>
```

Parameters

<1-16777214>

Flexible Algorithm IPv4 TE metric value.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# interface eth 1  
OcNOS(config-if)# isis te-minimum-delay flex-algo 1
```

extended-admin-group

Use this command to associate an Extended Admin Group (EAG) name.

Use the `no` form of this command to disassociate an EAG name.

Command Syntax

```
extend-admin-group (NAME)  
no extend-admin-group (NAME)
```

Parameters

NAME

Specifies the name of the affinity map.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# Interface eth1
```

```
OcNOS(config-if)# isis extended-admin-group flex-algo 128
```

isis extended-admin-group flex-algo

Use this command to set the affinity, i.e. Extended Admin Group (EAG) on a routing enabled, interface for the Flexible Algorithm application.

Use the `no` form of this command to remove the affinity, i.e. EAG on a routing enabled, interface for the Flexible Algorithm application.

Command Syntax

```
isis extended-admin-group flex-algo (NAME)  
no isis extended-admin-group flex-algo (NAME)
```

Parameters

NAME

Specifies the Flex-Algorithm ID that will be associated with an Extended Admin Group.

Default

None

Command Mode

Configuration and Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# Interface eth 1  
OcNOS(config-if)# isis extended-admin-group flex-algo 10
```

extended-admin-group flex anomaly

Use this command to enable anomaly detection for the Extended Admin Group (EAG) in IS-IS.

Use the `no` form of this command to disable the enable anomaly detection for the Extended Admin Group (EAG) in IS-IS.

Command Syntax

extended-admin-group anomaly NAME

```
no extended-admin-group anomaly NAME
```

Parameters

NAME

Specifies the Flex-Algorithm ID anomaly name will be associated with an Extended Admin Group.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# Interface eth 1
OcNOS(config-if)# isis extended-admin-group flex anomaly red
```

isis extended-admin-group flex anomaly

Use this command to detect anomalies in the Extended Admin Group (EAG) configuration for a specific Flex-Algo in IS-IS.

Use the `no` form of this command to disable anomalies in the Extended Admin Group (EAG) configuration for a specific Flex-Algo in IS-IS.

Command Syntax

```
isis extended-admin-group flex-algo anomaly NAME
no isis extended-admin-group flex-algo anomaly NAME
```

Parameters

NAME

Name of Extended Administrative Group (EAG) to be advertised during anomalous Link delay performance.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# Interface eth 1
OcNOS(config-if)# isis extended-admin-group flex anomaly 100
```

isis admin-group anomaly flex-algo

Use this command to detect anomalies in the Admin Group configuration for a specific Flex-Algo in IS-IS.

Use the `no` form of this command to disable anomalies in the Admin Group configuration for a specific Flex-Algo in IS-IS.

Command Syntax

```
isis admin-group flex-algo (anomaly|) NAME
no isis admin-group anomaly flex-algo (anomaly|) NAME
```

Parameters

NAME

Name of extended administrative group (EAG) to be advertised during anomalous Link delay performance.

Anomaly

Name of anomaly for a specific Flex-Algo in IS-IS.

Default

None

Command Mode

Interface Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
OcNOS(config)# interface eth 1
OcNOS(config-if)# isis admin-group flex-algo anomaly 50
```

show isis flex-algo

Use this command to display information about the flexible algorithm configuration and operational state in IS-IS.

Command Syntax

```
show isis flex-algo <128-255> (all) (control)
```

Parameters

<128-255>

Specifies the flexible algorithm number <128-255>

all

Specifies all flexible algorithms.

control

Specifies flexible algorithm global control.

Default

None

Command Mode

Execution Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

```
show isis flex-algo all control
IS-IS Flex-Algo Control Information
=====
Instance: ISIS-1
Flex-Algo Support: Enabled
Flex-Algo Count: 3 (128, 150, 160)

Algorithm Details:
-----
Flex-Algo 128:
  Computation: SPF
  Metric Type: IGP
  Operational Status: Active
  Prefix-SID Allocation: Static
```

show isis flex-algo number status

Use this command to display status information for a specific Flexible Algorithm identified by (128-255).

Command Syntax

```
show isis flex-algo <128-255> status (election|usercfg|winner)
```

Parameters

<128-255>

Specifies the Flex-Algo ID.

status

Retrieves the current status of the specified Flex-Algo.

usercfg

Displays the algorithms that have been manually configured by the user on the device.

winner

Displays which algorithm has been selected for path computation based on the election process.

detail

Displays in detail user configuration of flexible algorithm of local router node.

Default

None

Command Mode

Execution Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

View Election Status for Flexible Algorithm:

```
show isis flex-algo 150 status winner
OcNOS#show isis flex-algo all status winner summary
isis Instance : 1
Received FAD table of Algorithm (141)is empty
```

show isis flex-algo all status usercfg

Use this command to display the details of flexible algorithm.

Command Syntax

```
show isis flex-algo all status usercfg (summary|detail))
```

Parameters

<128-255>

Specifies the Flex-Algo ID

all

Displays information for all IS-IS instances.

status

Retrieves the current status of the specified Flex-Algo

usercfg

Displays the user-configured settings for Flex-Algo.

summary

Displays a summary of user configuration of all flexible algorithm(s) of local router node.

detail

Displays in detail user configuration of all flexible algorithm(s) of local router node.

Default

None

Command Mode

Execution Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

View isis Status for Flexible Algorithm:

```
Flex-Algo 150 User Configuration Summary
=====
Instance: ISIS-1
Algorithm: 150
Computation: SPF
Metric Type: IGP
Prefix Metric: Enabled
Advertisement Mode: Per-Area
Flex-Algo Definition Source: User-Configured

Constraints:
-----
SRLG Constraints: None
```

```
Affinity Constraints: Include Red, Exclude Blue
Segment Routing Enabled: Yes
Prefix-SID Allocation: Dynamic

Operational Status: Active
```

show isis flex-algo all status winner

Use this command to displays a summary all flexible algorithm's FAD that have been declared as election winner across all routers of the SR domain.

Command Syntax

```
show isis flex-algo <128-255> all status winner (summary|detail)
```

Parameters

<128-255>

Specifies the Flex-Algo ID

all

Displays information for all IS-IS instances.

status

Retrieves the current status of the specified Flex-Algo

winner

Displays the winning node(s) elected for the Flex-Algo.

summary

Displays a brief overview of the election results.

detail

Provides an in-depth view of the election, including metrics and path information.

Default

None

Command Mode

Execution Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

View Election Status for Flexible Algorithm:

```
show isis flex-algo 128 all status winner summary
Flex-Algo 128 Status Winner
=====
Instance: ISIS-1
Algorithm: 128
Computation: SPF
Metric Type: IGP

Winning Node: 192.168.1.1
Winning Metric: 10
```



```
Winning Path: 192.168.1.1 → 192.168.2.2 → 192.168.3.3
Winning Node Role: Primary Path

Backup Path Available: Yes
Backup Path: 192.168.1.1 → 192.168.4.4 → 192.168.3.3
Backup Metric: 12
```

show isis extend-admin-groups

Use this command to display the global extended admin group mapping table (Affinity map).

Command Syntax

```
show isis extend-admin-groups
```

Parameters

None

Default

None

Command Mode

Execution Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

View Election Status for Flexible Algorithm:

```
show isis extend-admin-groups
IS-IS Extended Administrative Groups
=====
Instance: ISIS-1
Interface: GigabitEthernet0/0/0
  Extended Admin Groups:
    Group 1: Green
    Group 2: Blue
    Group 3: Red

Interface: GigabitEthernet0/0/1
  Extended Admin Groups:
    Group 1: Green
    Group 4: Yellow

Operational Status: Active
```

show isis flex-algo all status

Use this command to display the status of all Flexible Algorithms in the IS-IS protocol.

Command Syntax

```
show isis flex-algo all status (election|userconfig|winner(summary|detail))
```

Parameters

election

Displays whether the algorithm is part of a group of algorithms being elected to handle the path computation.

usercfg

Displays the algorithms that have been manually configured by the user on the device.

winner

Displays which algorithm has been selected for path computation based on the election process.

summary

Displays a summary of user configuration of flexible algorithm of local router node.

detail

Displays in detail user configuration of flexible algorithm of local router node.

Default

None

Command Mode

Execution Mode

Applicability

Introduced in OcNOS version 6.6.0.

Example

View Election Status for all Flexible Algorithms:

```
Flex-Algo 150 Status Election
=====
Instance: ISIS-1
Algorithm: 150
Computation: SPF
Metric Type: IGP
Prefix Metric: Enabled
Advertisement Mode: Per-Area
Flex-Algo Definition Source: Local

Node Election Status:
-----
Local Node Participating: Yes
Computation Algorithm Used: SPF
Number of Elected Nodes: 4
Elected Node IDs: 10.1.1.1, 10.1.1.2, 10.1.1.3, 10.1.1.4

SRLG Constraints: None
Affinity Constraints: None
Operational Status: Active
```

FTN Fallback Support for Flexible Algorithms

Flexible Algorithm (Flex-Algo) enables an IGP to compute paths based on specific constraints and topology attributes, providing distributed traffic-engineering capabilities. These algorithms allow users to define differentiated forwarding paths that meet various performance or resource objectives. Service routes that carry a color attribute can be steered through Flex-Algo-based transport paths using SR-ODN templates.

In previous software versions, services mapped to a particular Flex-Algo FTN had no protection if that FTN became unavailable. When the primary Flex-Algo transport path failed, the affected service FTNs were removed because no alternate path selection was supported, even if valid Native-SR or other Flex-Algo options existed in the network.

The Flex-Algo Fallback feature introduces a mechanism to maintain service continuity during Flex-Algo transport failures. With this enhancement, colored services can automatically move to an alternate transport FTN when their primary Flex-Algo FTN goes down. The fallback can be directed either to a Native-SR FTN (ISIS-SR or OSPF-SR) or to a secondary Flex-Algo FTN defined by the user.



Note: Only one fallback method is configured per color.

Feature Characteristics

- **Fallback Mechanism:** Provides a configurable fallback FTN if the primary FA-FTN is not available.
- **Service Continuity:** Ensures that colored services remain mapped to a valid FTN without manual intervention.
- **Flexible Configuration:** Allows fallback to either the native SR-FTN or another designated FTN.
- **Failure Handling:** Automatically activates the fallback path during FA-FTN failure or unavailability.
- **User Control:** Administrators can explicitly define the fallback preference.

Benefits

This feature offers several key advantages:

- **High Availability:** Maintains uninterrupted forwarding even when the Flex-Algo FTN is down.
- **Operational Resilience:** Reduces service disruption during control-plane or Flex-Algo-specific failures.
- **Simplified Management:** Eliminates the need for manual reconfiguration during FTN failures.
- **Enhanced Flexibility:** Provides fallback options to align with network design policies.
- **Improved Reliability:** Ensures service-level agreements (SLAs) are met by avoiding traffic blackholing.

Prerequisites

This feature requires the following:

- Ensure that SR-MPLS (ISIS-SR) is enabled and operational in the network.
- Loopback interfaces are configured with prefix-SIDs for each Flex-Algo instance.
- Flex-Algo instances (for example, 128 and 129) are defined with appropriate metric types.
- MPLS TE is enabled with a valid SRGB range and router ID.

Configuration

The following configuration enables Flex Algo FTn Fallback.

Topology

This topology is validated on a multi-node ISIS SR network comprising both core and edge routers. The topology demonstrates the interaction between Flex-Algo paths and the fallback mechanism that ensures continuous forwarding when the preferred algorithm becomes unavailable.

Master Topology:

The master topology consists of a single ISIS area with multiple interconnected routers forming the SR domain.

Core Routers (RTR2, RTR4, RTR5, and RTR6): Establish the SR-MPLS transport core and participate in multiple Flex-Algo computations.

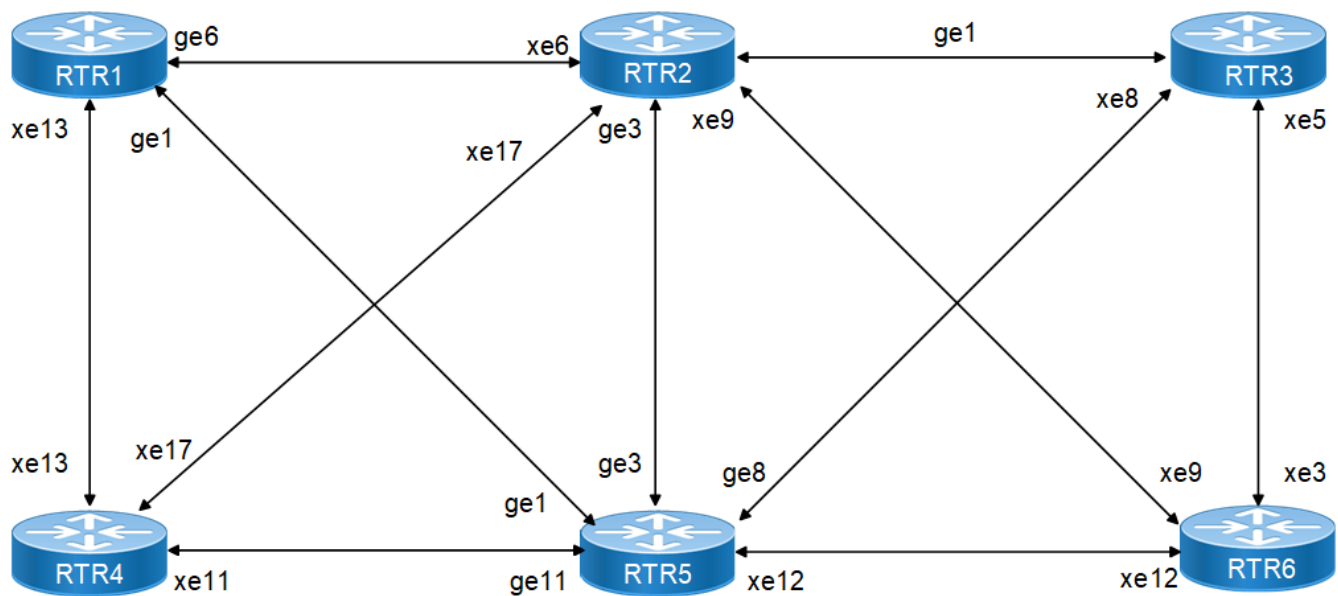
Edge Routers (RTR1 and RTR3): Act as ingress and egress service endpoints where SR policies are instantiated, and FTN mappings are maintained.

Connectivity: All routers are interconnected through redundant point-to-point links, providing diverse ECMP paths to test algorithm-specific routing and fallback behavior.

ISIS-SR Configuration: Each node advertises prefix-SIDs, adjacency-SIDs, and algorithm-SIDs in the ISIS LSDB. A consistent SRGB allocation across the topology ensures uniform label indexing.

This topology enables deterministic validation of route computation, label programming, and FTN switching between algorithms under failure conditions.

Figure 11. Master Topology



Logical Topology – Flex-Algo 128

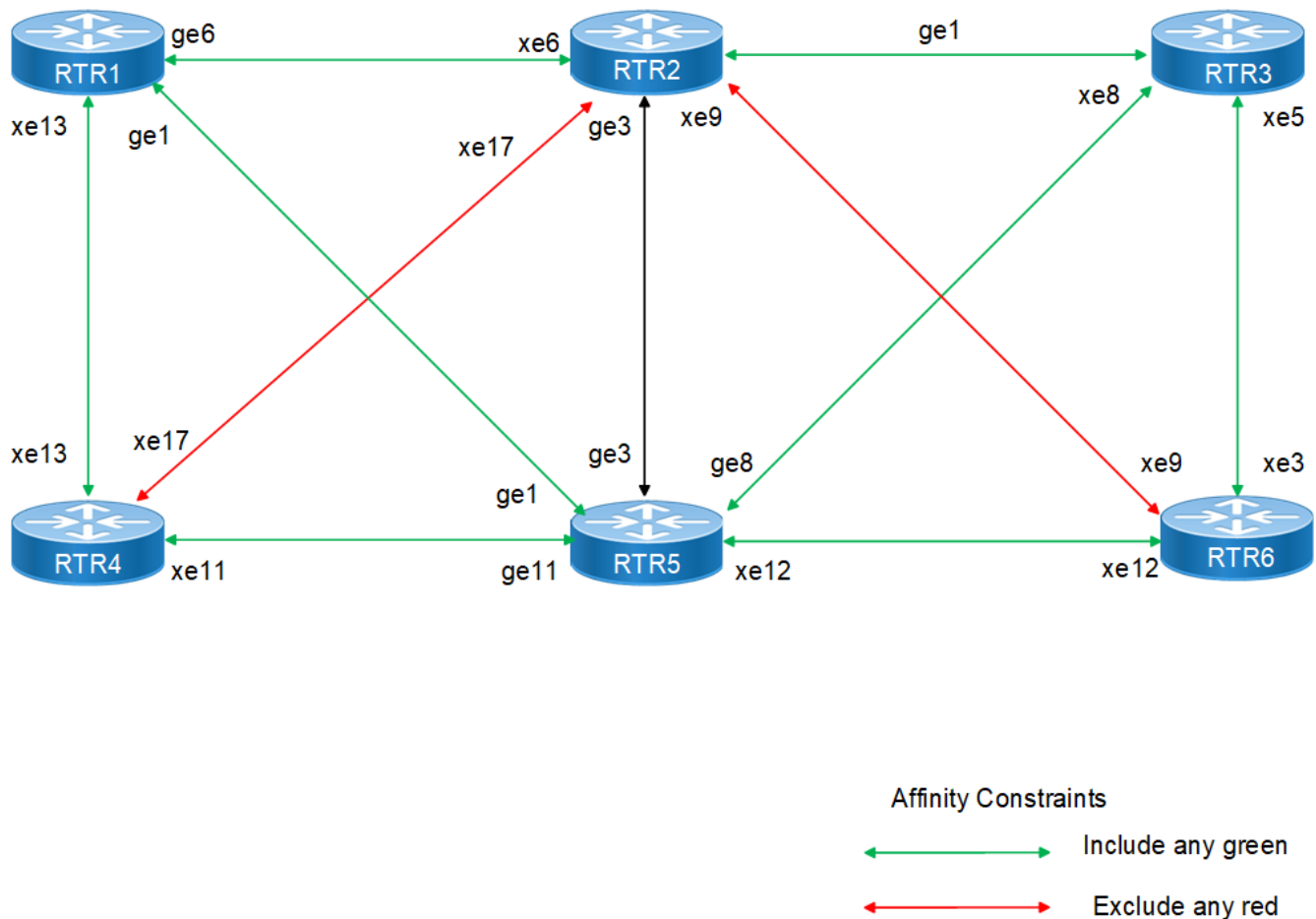
Flex-Algo 128 represents the primary algorithm for BGP-VPLS and L3VPN services.

Computation Scope: FA128 excludes certain links based on affinity or metric constraints to simulate a traffic-engineered path through selected core routers.

Traffic Steering: Under normal operation, traffic from RTR1 to RTR3 is label-switched along the FA128 path using the SIDs derived from the algorithm-specific SPF computation.

Fallback Behavior: When the preferred FA128 route is withdrawn or the FA128 SID becomes invalid, the ingress router automatically reprograms the FTN entry to use the Native SR.

Figure 12. Logical Topology – Flex-Algo 128



Logical Topology – Flex-Algo 129

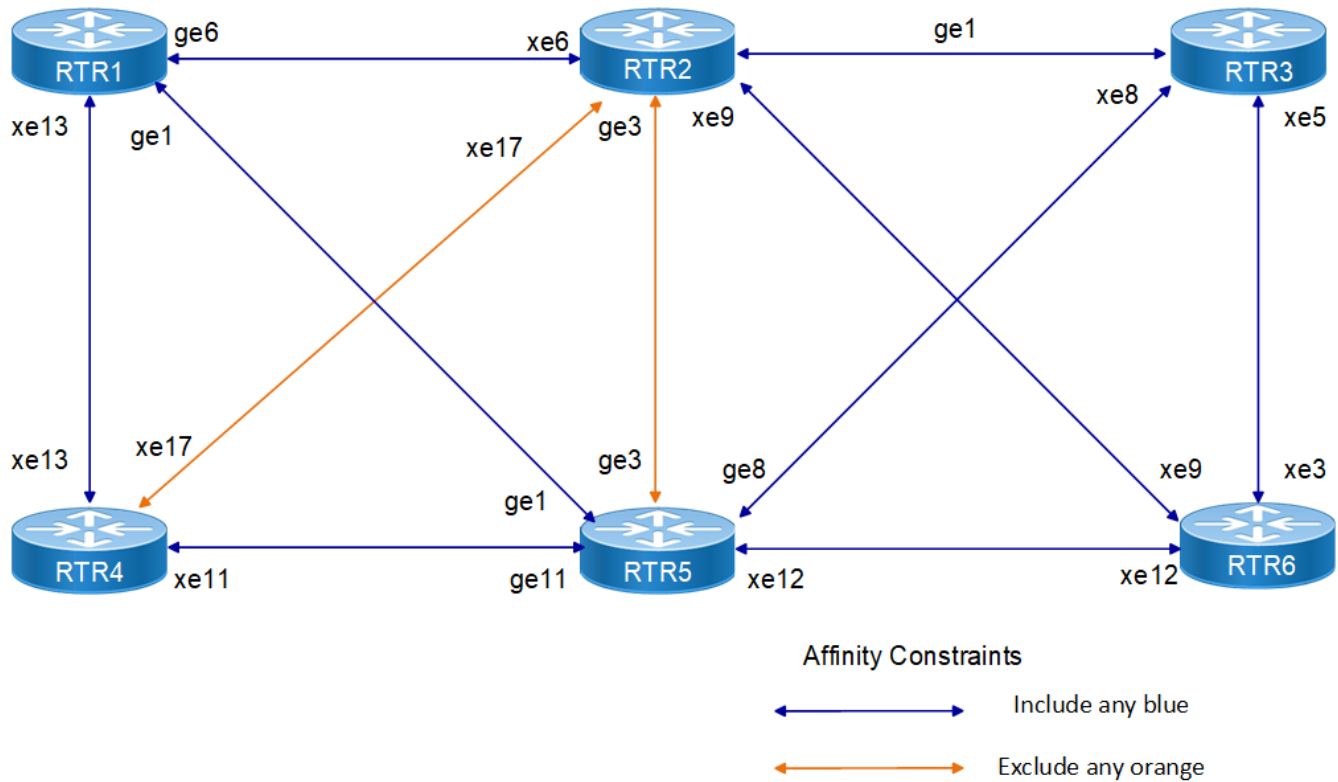
Flex-Algo 129 represents the primary algorithm for ELINE and ELAN services.

Computation Scope: FA129 includes additional links excluded from FA128 computations, providing a resilient backup path.

Fallback Behavior: When the preferred FA129 route is withdrawn or the FA129 SID becomes invalid, the ingress router automatically reprograms the FTN entry to use the another FA128.

Operational Continuity: The fallback occurs transparently within the forwarding plane, ensuring uninterrupted traffic delivery without manual intervention.

Figure 13. Logical Topology – Flex-Algo 129



To configure FTN fallback functionality on nodes, follow the steps :

1. Enable Segment Routing and define the Segment Routing Global Block (SRGB) range used for label allocation.

```
segment-routing
global block 20000 80000
```

2. Enable SR-TE to activate dynamic and color-based path computation based on ON Demand Next-Hop(ODN) template.

```
segment-routing
traffic-engineering
```

3. Configure Flex-Algo Instances under IS-IS to define Flex-Algo IDs and specify metric types, affinities, and priorities.

```
router isis 1
capability flex-algo routing
flex-algo 128
metric-type te-metric
priority 130
exit-flex-algo
!
flex-algo 129
metric-type link-delay
priority 131
exit-flex-algo
!
```



Notes: Each algorithm represents an independent topology derived from IS-IS attributes.

- Algorithm 128 computes paths based on TE metrics.
- Algorithm 129 computes paths based on link-delay, suitable for latency-sensitive services.

4. Assign Prefix-SIDs to advertise the router's loopback address in each Flex-Algo topology. This enables other routers to compute paths toward the node using the appropriate algorithm.

```
interface loopback2
 ip address 25.0.1.1/32 secondary
 prefix-sid index 1
 prefix-sid algorithm-num 128 index 1281
 prefix-sid algorithm-num 129 index 1291
 ip router isis 1
```

5. Configure TE and delay parameters under participating interfaces so that Flex-Algo can calculate paths based on topology constraints. These parameters ensure that IS-IS advertises per-algorithm TE metrics, link delays, and admin-group affinities to influence path selection.

```
interface gel
 load-interval 30
 ip address 11.0.15.1/24
 mtu 9216
 label-switching
 isis network point-to-point
 ip router isis 1
 isis te-metric flex-algo ipv4 20
 isis te-minimum-delay flex-algo 30
 isis te-maximum-delay flex-algo 40
 isis extended-admin-group flex-algo green
 isis extended-admin-group flex-algo blue
```

6. Define color-based ODN mappings and associate each color with a Flex-Algo instance and a fallback option. When the primary Flex-Algo path becomes unavailable, the router automatically switches to the defined fallback algorithm or native SR topology.

```
segment-routing
 traffic-engineering
  on-demand-nexthop 32
   flex-algo 128
   fallback flex-algo 129
  exit-sr-odn
  !
  on-demand-nexthop 34
   flex-algo 128
   fallback native-sr
  exit-sr-odn
  !
exit-te
```



Notes: The router dynamically creates SR policies based on these mappings.

- Color 32 → Primary = Flex-Algo 129; Fallback to Flex-Algo 128
- Color 34 → Primary = Flex-Algo 128; Fallback to Native SR topology.

7. Assign a stable router ID for MPLS TE to guarantee deterministic path computation across SR-TE policies. This ensures that the router consistently uses the same loopback address for all SR-TE operations and Flex-Algo advertisements.

```
router isis 1
```

```
mpls traffic-eng router-id 25.0.1.1
mpls traffic-eng level-2
```

Validation

Verify the fallback and restore mechanism:

```

RTR1#show mpls forwarding-table algorithm 129
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: Disabled

Code   FEC           Nexthop    FTN-ID    Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC                Algo-Num  UpTime
-----
i>    25.0.1.2/32    11        28        -         -         -     -         -
      -             129       15:02:08  27        0         Yes    21292      ge1
11.0.15.5 -         -         8         -         -         -     -         -
i>    25.0.1.4/32    2         8         -         -         -     -         -
      -             129       15:02:52  1         0         Yes    3          xe13
11.0.14.4 -         -         15        -         -         -     -         -
i>    25.0.1.5/32    6         15        -         -         -     -         -
      -             129       15:02:41  13        0         Yes    3          ge1
11.0.15.5 -         -         34        -         -         -     -         -
i>    25.0.1.6/32    13        34        -         -         -     -         -
      -             129       15:02:08  33        0         Yes    21296      ge1
11.0.15.5 -         -         33        0         Yes    21296      ge1

RTR1#
RTR1#
RTR1#shwo mp
RTR1#show mpls dep-up table
=====
Route-Node Prefix: 25.0.1.3
=====
CLIST-INFO:
  c_list-Pointer = 3126ea5c
  c_list-Type    = CONFIRM_NODE_FTN
  c_list-Prefix  = 25.0.1.3/32
  c_list-Count   = 5
-----
CONFIRM-NODE INFO:
  Confirm-Node-Pointer = 3130309c
  Confirm-Data-Pointer = 30f202dc
  Confirm-Node-Type    = CONFIRM_EVPN
  EVPN-ID              = 2000
  Destination Peer     = 25.0.1.3
  Color                = 33
  Parent-FTN-Pointer   = 31465df4
  Parent-FTN-Index     = 14
  Parent-FTN-Name      = N/A
  Parent-FTN-Owner     = ISIS-SR-FA
  Parent-FTN-Algo-Num  = 128
                                     =====> Falls back to another flex-algo 128
CONFIRM-NODE INFO:
  Confirm-Node-Pointer = 3130300c
  Confirm-Data-Pointer = 30eba8ec
  Confirm-Node-Type    = CONFIRM_EVPN
  EVPN-ID              = 1500
  Destination Peer     = 25.0.1.3
  Color                = 32
  Parent-FTN-Pointer   = 31465df4
  Parent-FTN-Index     = 14
  Parent-FTN-Name      = N/A

```



```

    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128                =====> Falls back to another flex-algo 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = 3130324c
    Confirm-Data-Pointer  = 30f3163c
    Confirm-Node-Type     = CONFIRM_VPLS_MESH_VC
    VPLS Id               = 3000
    Peer address          = 25.0.1.3/32
    Color                 = 34
    Parent-FTN-Pointer    = 31465df4
    Parent-FTN-Index      = 14
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = 3130312c
    Confirm-Data-Pointer  = 31466504
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 200.1.1.0/24
    Color                 = 36
    Parent-FTN-Index-H    = 14 (0x7f7731465df4)
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
    Confirm-Pointer-H     = 0x7f773130312c
    Confirm-prefix-H      = 25.0.1.3/32
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = 313031bc
    Confirm-Data-Pointer  = 3146688c
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 200::/64
    Parent-FTN-Index-H    = 9 (0x7f7731464c4c)
    Parent-FTN-Owner      = ISIS-SR
    Confirm-Pointer-H     = 0x7f77313031bc
    Confirm-prefix-H      = 25.0.1.3/32
RTR1#
RTR1#

```

```

RTR1#show mpls forwarding-table 25.0.1.3/32 algorithm 129
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: Disabled
Code   FEC           FTN-ID   Nhife-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC           Nexthop   Algo-Num  UpTime
i>    25.0.1.3/32    12        49        -          -     -          -
      -             129       00:00:31  0          Yes   21293     ge1       No
11.0.15.5 - - - 36
RTR1#
RTR1#show mpls forwarding-table algorithm 129
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: Disabled
Code   FEC           FTN-ID   Nhife-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC           Nexthop   Algo-Num  UpTime
i>    25.0.1.2/32    11        28        -          -     -          -
      -             129       15:13:02  0          Yes   21292     ge1       No
11.0.15.5 - - - 27
i>    25.0.1.3/32    12        49        -          -     -          -
      -             129       00:00:40  0          Yes   21293     ge1       No

```

```

11.0.15.5      -      -
i> 25.0.1.4/32  2      8      -      -      -      -
      -      129     15:13:46
                        1      0      Yes  3      xe13      No
11.0.14.4      -      -
i> 25.0.1.5/32  6      15     -      -      -      -
      -      129     15:13:35
                        13     0      Yes  3      ge1       No
11.0.15.5      -      -
i> 25.0.1.6/32  13     34     -      -      -      -
      -      129     15:13:02
                        33     0      Yes  21296    ge1       No
11.0.15.5      -      -
RTR1#
RTR1#
RTR1#show mpls dep-up table
=====
Route-Node Prefix: 25.0.1.3
=====
CLIST-INFO:
  c_list-Pointer = 3126ea5c
  c_list-Type    = CONFIRM_NODE_FTN
  c_list-Prefix  = 25.0.1.3/32
  c_list-Count   = 5
-----
CONFIRM-NODE INFO:
  Confirm-Node-Pointer = 3130309c
  Confirm-Data-Pointer = 30f202dc
  Confirm-Node-Type    = CONFIRM_EVPN
  EVPN-ID              = 2000
  Destination Peer     = 25.0.1.3
  Color                = 33
  Parent-FTN-Pointer   = 314656e4
  Parent-FTN-Index     = 12
  Parent-FTN-Name      = N/A
  Parent-FTN-Owner     = ISIS-SR-FA
  Parent-FTN-Algo-Num  = 129
                                     =====> Restored to primary FA129
CONFIRM-NODE INFO:
  Confirm-Node-Pointer = 3130300c
  Confirm-Data-Pointer = 30eba8ec
  Confirm-Node-Type    = CONFIRM_EVPN
  EVPN-ID              = 1500
  Destination Peer     = 25.0.1.3
  Color                = 32
  Parent-FTN-Pointer   = 314656e4
  Parent-FTN-Index     = 12
  Parent-FTN-Name      = N/A
  Parent-FTN-Owner     = ISIS-SR-FA
  Parent-FTN-Algo-Num  = 129
                                     =====> Restored to primary FA129
CONFIRM-NODE INFO:
  Confirm-Node-Pointer = 3130324c
  Confirm-Data-Pointer = 30f3163c
  Confirm-Node-Type    = CONFIRM_VPLS_MESH_VC
  VPLS Id              = 3000
  Peer addrss          = 25.0.1.3/32
  Color                = 34
  Parent-FTN-Pointer   = 31465df4
  Parent-FTN-Index     = 14
  Parent-FTN-Name      = N/A
  Parent-FTN-Owner     = ISIS-SR-FA
  Parent-FTN-Algo-Num  = 128
CONFIRM-NODE INFO:
  Confirm-Node-Pointer = 3130312c
  Confirm-Data-Pointer = 31466504
  Confirm-Node-Type    = CONFIRM_VRF
  Fec-Prefix           = 200.1.1.0/24
  Color                = 36
  Parent-FTN-Index-H   = 14 (0x7f7731465df4)

```

```
Parent-FTN-Owner      = ISIS-SR-FA
Parent-FTN-Algo-Num   = 128
Confirm-Pointer-H     = 0x7f773130312c
Confirm-prefix-H      = 25.0.1.3/32
CONFIRM-NODE INFO:
Confirm-Node-Pointer  = 313031bc
Confirm-Data-Pointer  = 3146688c
Confirm-Node-Type     = CONFIRM_VRF
Fec-Prefix            = 200::/64
Parent-FTN-Index-H    = 9 (0x7f7731464c4c)
Parent-FTN-Owner      = ISIS-SR
Confirm-Pointer-H     = 0x7f77313031bc
Confirm-prefix-H      = 25.0.1.3/32
RTR1#
```

Fallback Flex-Algo Commands

This section describes the fallback flex-algo commands:

fallback flex-algo

Use this command to configure another flex-algo as a fallback mechanism for the primary flex-algo in SR-ODN template.

Use the **no** form of the command to remove the flex-algo as fallback option.

Command Syntax

```
fallback flex-algo <value>  
no fallback flex-algo <value>
```

Parameters

None

Default

Disabled

Command Mode

On Demand Nexthop Mode(ODN Mode)

Applicability

This command was introduced in OcNOS version 7.0.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #flex-algo 128  
OcNOS (config-sr-odn) #fallback flex-algo 129
```

fallback native-sr

Use this command to configure native-sr as a fallback mechanism for the primary flex-algo in SR-ODN template. Use the **no** form of the command to remove the native-sr as fallback option.

Command Syntax

```
fallback native-sr  
no fallback native-sr
```

Parameters

None

Default

Not configured

Command Mode

On Demand Nexthop Mode(ODN Mode)

Applicability

This command was introduced in OcNOS version 7.0.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #flex-algo 128  
OcNOS (config-sr-odn) #fallback native-sr
```

flex-algo

Use this command to configure the flex-algo value associated with an SR-ODN instance.

Use the **no** form of the command to remove the flex-algo configured in an SR-ODN instance.

Command Syntax

```
flex-algo <128-255>  
no flex-algo
```

Parameters

<1-65535>

Flex-Algo value associated with ODN instance

Default

Not configured

Command Mode

On Demand Nexthop Mode(ODN Mode)

Applicability

This command was introduced in OcNOS version 7.0.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 105  
OcNOS (config-sr-odn) #flex-algo 128
```

Implementation Examples

Multi-service environments with differentiated fallback strategies

A network carries different classes of services (for example: enterprise L3VPN, EVPN-based data center interconnects, and VPLS). Each group has unique performance needs and fallback behavior.

Implementation:

Enterprise L3VPN (color 36): Primary FA 128 → Fallback Native SR

ELAN (color 32): Primary FA 129 → Fallback FA128

BGP-VPLS (color 34): Primary FA 128 → No fallback configured (strict TE compliance)

Each service group receives behavior matching its requirement—high resiliency, predictable routing, or strict TE path control.

Automatic recovery after topology restoration

Flex-Algo 128 fails, causing services to fall back to Native-SR. Later, restoring the primary FA 128 path the traffic restores from Native SR path to the FA 128 path.

Glossary

Key Terms/Acronym	Description
Flexible Algorithm (Flex-Algo):	An IGP enhancement that computes paths based on operator-defined constraints (e.g., delay, link attributes, resource affinities). Each algorithm operates as a separate topology slice.
FTN - FEC to NHLFE (Frequent Equivalent Class to Next Hop Label Forwarding Entry)	A forwarding construct used to install MPLS-based transport entries. Flex-Algo FTNs and SR FTNs represent different transport options.
Native-SR FTN	A transport FTN derived directly from the IGP Segment Routing topology (ISIS-SR or OSPF-SR). Used as a generic SR path without Flex-Algo constraints.
Fallback Flex-Algo	An alternate Flex-Algo that can be used if the primary Flex-Algo transport becomes unavailable.

Traffic Steering for Flexible Algorithms

Traffic Steering for Flexible Algorithms feature integrates BGP On-Demand Next Hop (ODN) policies with Flexible Algorithms to improve the efficiency of path computation. FlexAlgo allow for route selection based on specific network constraints such as latency, bandwidth, and other performance metrics. By combining BGP ODN policies with Flexible Algorithms, the network can dynamically compute and adjust optimal paths in real-time, ensuring effective traffic management according to service requirements.

Feature Characteristics

- **Coloring for Traffic Steering:**
 - The egress PE node assigns colors to MPLS service FTNs.
 - These colors represent SR-TE SLA requirements and are advertised via BGP UPDATE messages to the ingress PE node.
 - The ingress node matches the color information with the corresponding ODN policy and steers the traffic accordingly (Traffic Steering).
- **Integration with Flexible Algorithms:**
 - ODN policies can be combined with Flexible Algorithms to create Flex-Algo-based SR-MPLS BE tunnels (Flex-Algo LSPs).
 - These tunnels enhance path computation by allowing route selection based on constraints such as latency, bandwidth, and traffic load.
 - Network operators can customize routing logic to optimize traffic flow and enhance network efficiency.
- **Support for Multiple MPLS Services:**
 - Flex-Algo LSPs can be used with:
 - VPLS (Signaling via BGP)
 - BGP VPNv4
 - BGP VPNv6
 - EVPN (ELINE, ELAN, ETREE)

Benefits

This feature offers several key advantages:

- Traffic steering based on SR-TE SLA requirements, ensuring optimal path selection.
- Customizable routing logic using Flexible Algorithms, tailored to constraints like latency, bandwidth, and traffic load.
- Dynamic network adaptation, which reduces the need for manual intervention and minimizes complexity.
- Efficient resource utilization through Flex-Algo LSPs, optimizing traffic routing.
- Policy-driven traffic steering, enhancing resource allocation and overall network performance.
- Real-time path adjustments in response to congestion, failures, or changes in SLA.

Prerequisites

This feature requires the following device capabilities:

- OcNOS devices must support:
- ISIS-SR Flex-Algo and ECMP
- BGP-VPLS and L3VPN/6VPE services
- EVPN services

Configuration

The following configuration enables Flex Algo with ISIS-SR.

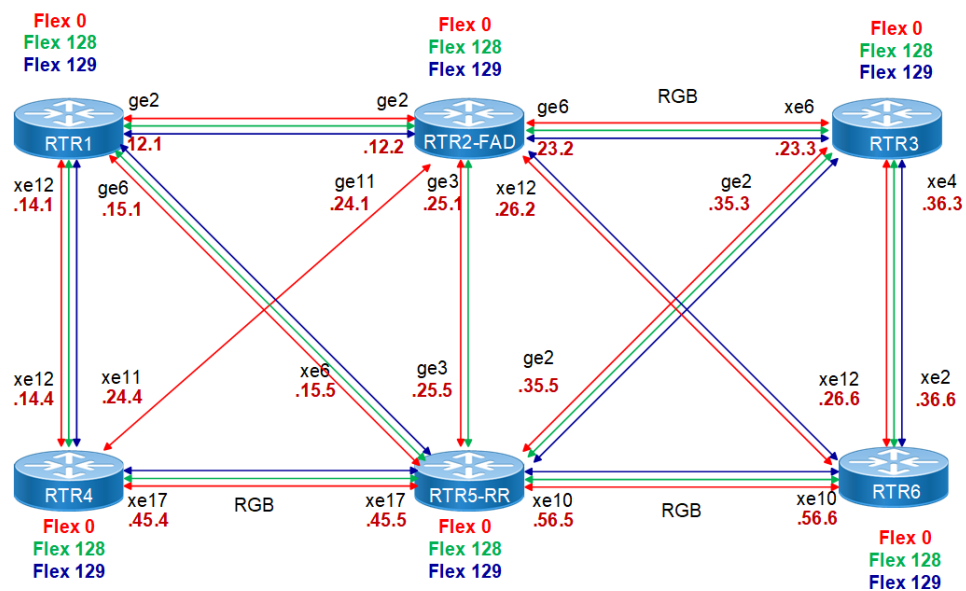
Topology

This topology represents the application of Flex-Algo in a SR network environment, with three distinct algorithms highlighted: Flex Algo 0, 128, and 129. Each algorithm defines a specific logical topology based on unique constraints and use cases.

Topology Visualization:

- Red Lines (Flex Algo 0): Represents the default IGP metric-based paths where all links contribute to general traffic forwarding.
- Green Lines (Flex Algo 128): Highlights paths optimized for bandwidth efficiency using GREEN-affinity links, filtering out non-compliant links.
- Blue Lines (Flex Algo 129): Displays paths optimized for delay-sensitive traffic using BLUE-affinity links, excluding all others.

Figure 14. Logical Topologies Based on Flexible Algorithms



Configuration for BGP-VPLS Traffic Steering with ODN for FlexAlgo

The following configuration enables BGP-VPLS Traffic Steering with ODN Policy.

- The goal is to extend the existing setup used in the section to configure BGP VPLS services over Flex-Algo 128.
- ODN policy will be used to automate the steering of VPLS traffic. This ensures that VPLS traffic follows the optimized paths based on Flex-Algo 128 constraints and metrics.
- The approach helps in seamless integration of VPLS over an SR-based network while maintaining traffic engineering flexibility.

To configure BGP-VPLS functionality on nodes between RTR1 to RTR3, follow the steps mentioned below:

1. Configure BGP for VPLS Services.

a. Set up BGP in L2VPN address family on RTR1 and RTR2 as below.

```
RTR1(config)#router bgp 65010
RTR1(config-router)# bgp auto-policy-soft-reset enable
RTR1(config-router)# neighbor 25.0.1.5 remote-as 65010
RTR1(config-router)# neighbor 25.0.1.5 update-source loopback2
RTR1(config-router)# end

RTR1(config-router)# address-family l2vpn vpls
RTR1(config-router-af)# neighbor 25.0.1.5 activate
RTR1(config-router-af)# exit-address-family
RTR1(config-router)# end

RTR1(config-router)# exit

RTR3(config)#router bgp 65010
RTR3(config-router)# bgp auto-policy-soft-reset enable
RTR3(config-router)# neighbor 25.0.1.5 remote-as 65010
RTR3(config-router)# neighbor 25.0.1.5 update-source loopback2
RTR1(config-router)# end

RTR3(config-router)# exit

RTR3(config-router)# address-family l2vpn vpls
RTR3(config-router-af)# neighbor 25.0.1.5 activate
RTR3(config-router-af)# exit-address-family
RTR1(config-router)# end

RTR3(config-router)# exit
```

b. Set up BGP in L2VPN address family on RTR3 which acts as RR below:

```
RTR5(config)#router bgp 65010
RTR5(config-router)# bgp auto-policy-soft-reset enable
RTR5(config-router)# no bgp inbound-route-filter
RTR5(config-router)# neighbor 25.0.1.1 remote-as 65010
RTR5(config-router)# neighbor 25.0.1.1 update-source loopback2
RTR5(config-router)# neighbor 25.0.1.3 remote-as 65010
RTR5(config-router)# neighbor 25.0.1.3 update-source loopback2
RTR5(config-router)# exit
RTR5(config-router)# address-family l2vpn vpls
RTR5(config-router-af)# neighbor 25.0.1.1 activate
RTR5(config-router-af)# neighbor 25.0.1.1 route-reflector-client
RTR5(config-router-af)# neighbor 25.0.1.3 activate
RTR5(config-router-af)# neighbor 25.0.1.3 route-reflector-client
RTR5(config-router-af)# exit-address-family
RTR5(config-router)# !
RTR5(config-router)# exit
```

2. Configure VPLS Instance on Between RTR1 and RTR3.

```
RTR1(config)#mpls vpls BGP-VPLS 1000
RTR1(config-vpls)# signaling bgp
RTR1(config-vpls-sig)# ve-id 1
RTR1(config-vpls-sig)# exit-signaling
RTR1(config-vpls)# exit-vpls
RTR1(config)#end
```

```
RTR3(config)#mpls vpls BGP-VPLS 1000
RTR3(config-vpls)# signaling bgp
RTR3(config-vpls-sig)# ve-id 1
RTR3(config-vpls-sig)# exit-signaling
RTR3(config-vpls)# exit-vpls
RTR3(config)#end
```



Note: Each VE-ID must be unique per node within the VPLS instance.

3. Configure the egress side to advertise the color per VPLS instance using a route-map:

a. Egress-side, Color needs to be advertised per vpls instance (as mentioned below).

```
RTR3(config)#route-map set_color permit 10
RTR3(config-route-map)# set extcommunity color 1000
RTR3(config-route-map)#!
```

```
RTR3(config)#
RTR3(config)#mpls vpls BGP-VPLS 1000
RTR3(config-vpls)#route-map set_color
RTR3(config-vpls)#exit
RTR3(config)#
```

4. Enable ODN Policy for Traffic Steering on RTR1:

```
RTR1(config)#segment-routing
RTR1(config-sr)# traffic-engineering
RTR1(config-sr-te)# on-demand-nexthop 1000
RTR1(config-sr-odn)# flex-algo 128
RTR1(config-sr-odn)# exit-sr-odn
RTR1(config-sr-te)# end
RTR1(config-sr-te)# exit-te
RTR1(config-sr)#
```

5. Configure ACCESS Interface for BGP-VPLS.

```
RTR1(config)#interface xe15
RTR1(config-if)# mtu 9216
RTR1(config)#interface xe15.1000 switchport
RTR1(config-if)# encapsulation dot1q 1000
RTR1(config-if)# mtu 9216
RTR1(config-if)# access-if-vpls
RTR1(config-acc-if-vpls)# mpls-vpls BGP-VPLS
RTR1(config-acc-if-vpls)#!
```

```
RTR1(config)#interface xe15
RTR1(config-if)# mtu 9216
RTR1(config)#interface xe19.1000 switchport
RTR1(config-if)# encapsulation dot1q 1000
RTR1(config-if)# mtu 9216
RTR1(config-if)# access-if-vpls
RTR1(config-acc-if-vpls)# mpls-vpls BGP-VPLS
RTR1(config-acc-if-vpls)#!
```

Configuration Sanapshot

RTR1

Configuration Sanapshot of RTR1

```
mpls vpls BGP-VPLS 1000
signaling bgp
ve-id 1
exit-signaling
exit-vpls

interface xe15
mtu 9216

interface xe15.1000 switchport
encapsulation dot1q 1000
mtu 9216
access-if-vpls
mpls-vpls BGP-VPLS

router bgp 65010
bgp auto-policy-soft-reset enable
address-family l2vpn vpls
neighbor 25.0.1.5 activate
exit-address-family

segment-routing
traffic-engineering
on-demand-nexthop 1000
flex-algo 128
exit-sr-odn
!
exit-te
```

RTR2-FAD

Configuration Sanapshot of RTR2-FAD

```
route-map set_color permit 10
set extcommunity color 1000

mpls vpls BGP-VPLS 1000
route-map set_color
signaling bgp
ve-id 3
exit-signaling
exit-vpls

interface xe19
mtu 9216

interface xe19.1000 switchport
encapsulation dot1q 1000
mtu 9216
access-if-vpls
mpls-vpls BGP-VPLS

router bgp 65010
bgp auto-policy-soft-reset enable
address-family l2vpn vpls
neighbor 25.0.1.5 activate
exit-address-family
```

RTR5

Configuration Sanapshot of RTR5

```
router bgp 65010
 no bgp inbound-route-filter
 bgp auto-policy-soft-reset enable
 address-family l2vpn vpls
 neighbor 25.0.1.1 activate
 neighbor 25.0.1.1 route-reflector-client
 neighbor 25.0.1.3 activate
 neighbor 25.0.1.3 route-reflector-client
 exit-address-family
 !
 exit
```

Validation

Verify the bgp vpls summary.

```
RTR1#show bgp l2vpn vpls summary
BGP router identifier 25.0.1.1, local AS number 65010
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
25.0.1.5         4 65010      157      160        1     0     0 01:01:15          1

Total number of neighbors 1

Total number of Established sessions 1

RTR1#show bgp l2vpn vpls detail

VPLS ID: 1000
VE-ID: 1
Discovered Peers: 1
Route-Target: 65010:1000
Local RD: 65010:1000
All Local Label Blocks:
[LB:81280, VBO:1, VBS:64]
Mesh Peers:
BGP Peer:25.0.1.5/32
VC Nbr Address:25.0.1.3, RD:65010:1000, VE-ID:3
VC Details: VC-ID:13
Local MTU:9216, Remote MTU:9216
Remote (LB:81280,VBO:1,VBS:64) Local (LB:81280,VBO:1,VBS:64)
LB sent on known VEID:Yes
In Label:81282, Out Label:81280
PW Status:Established
VC Installed:Yes
VC Signaled Time: 00:58:21
Extended-Community Color:1000

RTR1#
RTR1#show mpls dep-up table
=====
Route-Node Prefix: 25.0.1.3
=====
CLIST-INFO:
  c_list-Pointer = 3579d30
  c_list-Type    = CONFIRM_NODE_FTN
```

```

c_list-Prefix = 25.0.1.3/32
c_list-Count  = 1
-----
CONFIRM-NODE INFO:
Confirm-Node-Pointer = f4627000
Confirm-Data-Pointer = 30b1550
Confirm-Node-Type    = CONFIRM_VPLS_MESH_VC
VPLS Id              = 1000
Peer addrss          = 25.0.1.3/32
Color                = 1000
  Parent-FTN-Pointer = ec5d2040
  Parent-FTN-Index   = 6
  Parent-FTN-Name    = N/A
  Parent-FTN-Owner   = ISIS-SR-FA
  Parent-FTN-Algo-Num = 128

RTR1#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
1000        25.0.1.3        21283        81282     ge2           81280      2/Up     1
      BGP              Active      00:58:01   1000
RTR1#show mpls vpls detail
Virtual Private LAN Service Instance: BGP-VPLS, ID: 1000
SIG-Protocol: BGP
  Route-Distinguisher :65010:1000
  Route-Target :65010:1000
  VE-ID :1
Attachment-Circuit: UP
Learning: Enabled
Control-Word: Disabled
Flow Label Status: Disabled, Direction: None, Static: No
Group ID: 0, Configured MTU: 9216
Description: none
service-tpid: dot1q
Operating mode: Raw
MAC Withdrawal:

Configured interfaces:
Interface: xe15.1000
Status: Up
Subinterface Match Criteria(s) :
dot1q 1000

Mesh Peers:
  25.0.1.3 (Type: Ethernet) (Negotiated - CW: No, FAT: No) (Up) (UpTime: 00:58:16)

Verify FlexAlgo FTN entry and corresponding LSP information:

RTR1#show mpls ftn-table 25.0.1.3/32 algorithm 128
Primary FTN entry with FEC: 25.0.1.3/32, id: 6, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 01:19:25, UpTime: 01:19:25, LastUpdate: N/A
  Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none,
  Algorithm Number:128
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 22 refcount: 1
  Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 22, owner: ISIS-SR-FA, Stale: NO, refcount: 4, out intf: ge2, out
  label: 21283
  Nexthop addr: 11.0.12.2          cross connect ix: 8, op code: Push

```

```

Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 60 refcount: 1
Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
Out-segment with ix: 60, owner: ISIS-SR-FA, Stale: NO, refcount: 2, out intf: ge6, out
label: 21283
Nexthop addr: 11.0.15.5          cross connect ix: 8, op code: Push

Dependent service info (count 1):
[VPLS_MESH_VC] VPLS mesh vpls_id 1000 peer 25.0.1.3/32 out_label 81280 in_label 81282 opcode 8
Ext-Color 1000

```

Configuration for L3VPN (VPNv4) Traffic Steering with ODN for FlexAlgo

The following configuration enables L3VPN Traffic Steering with an ODN Policy:

- This setup extends the existing configuration from the section to support L3VPN services over Flex-Algo 128.
- ODN policy automates the steering of L3VPN traffic, ensuring it follows optimized paths based on the constraints and metrics defined for Flex-Algo 128.
- This approach enables seamless integration of L3VPN over an SR-based network while providing traffic engineering flexibility and efficient resource utilization.

1. Configure BGP On RTR1 and RTR3 which are PE routers and RTR5(RR).

a. Set up BGP in Address-Family VPNv4 on RTR1 and RTR3 as below.

```

RTR1(config)#router bgp 65010
RTR1(config-router)# bgp auto-policy-soft-reset enable
RTR1(config-router)# neighbor 25.0.1.5 remote-as 65010
RTR1(config-router)# neighbor 25.0.1.5 update-source loopback2
RTR1(config-router)# end
RTR1(config-router)# address-family vpnv4 unicast
RTR1(config-router-af)# neighbor 25.0.1.5 activate
RTR1(config-router-af)# exit-address-family
RTR1(config-router)# end
RTR1(config-router)# exit

RTR3(config)#router bgp 65010
RTR3(config-router)# bgp auto-policy-soft-reset enable
RTR3(config-router)# neighbor 25.0.1.5 remote-as 65010
RTR3(config-router)# neighbor 25.0.1.5 update-source loopback2
RTR3(config-router)# end
RTR3(config-router)# address-family vpnv4 unicast
RTR3(config-router-af)# neighbor 25.0.1.5 activate
RTR3(config-router-af)# exit-address-family
RTR3(config-router)# end
RTR3(config-router)# exit

```

b. Set up BGP in Address-Family VPNv4 on RTR5 which acts as RR below:

```

RTR5(config)#router bgp 65010
RTR5(config-router)# bgp auto-policy-soft-reset enable
RTR5(config-router)# no bgp inbound-route-filter
RTR5(config-router)# neighbor 25.0.1.1 remote-as 65010
RTR5(config-router)# neighbor 25.0.1.1 update-source loopback2
RTR5(config-router)# neighbor 25.0.1.3 remote-as 65010
RTR5(config-router)# neighbor 25.0.1.3 update-source loopback2
RTR5(config-router)# end
RTR5(config-router)# address-family vpnv4 unicast
RTR5(config-router-af)# neighbor 25.0.1.1 activate
RTR5(config-router-af)# neighbor 25.0.1.1 route-reflector-client

```



```
RTR5(config-router-af)# neighbor 25.0.1.3 activate
RTR5(config-router-af)# neighbor 25.0.1.3 route-reflector-client
RTR5(config-router-af)# exit-address-family
RTR5(config-router)# end
RTR5(config-router)# exit
```

2. Configure VRF on PE Routers (RTR1 and RTR3).

```
RTR1(config)#ip vrf vrf2000
RTR1(config-vrf)# rd 10:2000
RTR1(config-vrf)# route-target both 10:2000
```

```
RTR3(config)#ip vrf vrf2000
RTR3(config-vrf)# rd 10:2000
RTR3(config-vrf)# route-target both 10:2000
```

3. Enable BGP for VRF and Configure ACCESS-IF:

```
RTR1(config)#int xe15
RTR1(config-if)# mtu 9216
RTR1(config-if)#exit

RTR1(config)#
RTR1(config-if)#interface xe15.2000
RTR1(config-if)# encapsulation dot1q 2000
RTR1(config-if)# ip vrf forwarding vrf2000
RTR1(config-if)# ip address 100.1.1.1/24
RTR1(config-if)# mtu 9216
RTR1(config-if)#exit

RTR1(config)#
RTR1(config)#router bgp 65010
RTR1(config-router)# address-family ipv4 vrf vrf2000
RTR1(config-router-af)# redistribute connected
RTR1(config-router-af)# neighbor 100.1.1.2 remote-as 100
RTR1(config-router-af)# neighbor 100.1.1.2 activate
RTR1(config-router-af)# exit-address-family
RTR1(config-router)#end
RTR1(config-router)#commit
```

```
RTR3(config)#
RTR3(config)#int xe19
RTR3(config-if)# mtu 9216
RTR3(config-if)#exit
```

```
RTR3(config)#
RTR3(config-if)#interface xe19.2000
RTR3(config-if)# encapsulation dot1q 2000
RTR3(config-if)# ip vrf forwarding vrf2000
RTR3(config-if)# ip address 200.1.1.1/24
RTR3(config-if)# mtu 9216
RTR3(config-if)#exit
```

```
RTR3(config)#
RTR3(config)#router bgp 65010
RTR3(config-router)# address-family ipv4 vrf vrf2000
RTR3(config-router-af)# redistribute connected
RTR3(config-router-af)# neighbor 200.1.1.2 remote-as 200
RTR3(config-router-af)# neighbor 200.1.1.2 activate
RTR3(config-router-af)# exit-address-family
RTR3(config-router)#end
RTR3(config-router)#commit
```

4. Configure the egress side to advertise the color per VRF under address-family using a route-map.

```
RTR3(config)#
```

```

RTR3(config)#route-map set_color_vrf2000 permit 10
RTR3(config-route-map)#set extcommunity color 2000
RTR3(config-if)#exit

RTR3(config)#router bgp 65010
RTR3(config-router)# address-family ipv4 vrf vrf2000
RTR3(config-router-af)# redistribute connected route-map set_color_vrf2000
RTR3(config-router-af)# neighbor 200.1.1.2 route-map set_color_vrf2000 in
RTR3(config-router-af)# exit-address-family
RTR3(config-router)#

```

5. Enable ODN Policy for Traffic Steering on RTR1 for L3VPN routes coming from RTR3:

```

RTR1(config)#
RTR1(config)#segment-routing
RTR1(config-sr)# traffic-engineering
RTR1(config-sr-te)# on-demand-nexthop 2000
RTR1(config-sr-odn)# flex-algo 128
RTR1(config-sr-odn)# exit-sr-odn
RTR1(config-sr-te)# !
RTR1(config-sr-te)# exit-te
RTR1(config-sr)#commit

```

Configuration Snapshot

RTR1

The following is the running-config show output for the RTR1 router.

```

router bgp 65010
  bgp auto-policy-soft-reset enable
  neighbor 25.0.1.5 remote-as 65010
  neighbor 25.0.1.5 update-source loopback2
  !
  address-family vpnv4 unicast
    neighbor 25.0.1.5 activate
    exit-address-family
  !
  exit

ip vrf vrf2000
  rd 10:2000
  route-target both 10:2000

int xe15
  mtu 9216

interface xe15.2000
  encapsulation dot1q 2000
  ip vrf forwarding vrf2000
  ip address 100.1.1.1/24
  mtu 9216
  !
router bgp 65010
  address-family ipv4 vrf vrf2000
  redistribute connected
  neighbor 100.1.1.2 remote-as 100
  neighbor 100.1.1.2 activate
  exit-address-family
  !

segment-routing
  traffic-engineering

```

```
on-demand-nexthop 2000
flex-algo 128
exit-sr-odn
!
exit-te
```

RTR3

The following is the running-config show output for the RTR3 router.

```
router bgp 65010
bgp auto-policy-soft-reset enable
neighbor 25.0.1.5 remote-as 65010
neighbor 25.0.1.5 update-source loopback2
!
address-family vpnv4 unicast
neighbor 25.0.1.5 activate
exit-address-family
!
exit

ip vrf vrf2000
rd 10:2000
route-target both 10:2000

int xe19
mtu 9216

interface xe19.2000
encapsulation dot1q 2000
ip vrf forwarding vrf2000
ip address 200.1.1.1/24
mtu 9216

!
router bgp 65010
address-family ipv4 vrf vrf2000
redistribute connected
neighbor 200.1.1.2 remote-as 200
neighbor 200.1.1.2 activate
exit-address-family
!

route-map set_color_vrf2000 permit 10
set extcommunity color 2000

router bgp 65010
address-family ipv4 vrf vrf2000
redistribute connected route-map set_color_vrf2000
neighbor 200.1.1.2 remote-as 200
neighbor 200.1.1.2 activate
neighbor 200.1.1.2 route-map set_color_vrf2000 in
exit-address-family
```

RTR5

The following is the running-config show output for the RTR5 router.

```
router bgp 65010
bgp auto-policy-soft-reset enable
no bgp inbound-route-filter
neighbor 25.0.1.1 remote-as 65010
neighbor 25.0.1.1 update-source loopback2
neighbor 25.0.1.3 remote-as 65010
neighbor 25.0.1.3 update-source loopback2
```

```

!
address-family vpnv4 unicast
neighbor 25.0.1.1 activate
neighbor 25.0.1.1 route-reflector-client
neighbor 25.0.1.3 activate
neighbor 25.0.1.3 route-reflector-client
exit-address-family
!
exit

```

Validation

Ensure the VPNv4 routes are properly advertised and received across the BGP sessions. Check for correct route attributes and steering behaviors.:

```

RTR1#show ip bgp vpnv4 all summary
BGP router identifier 25.0.1.1, local AS number 65010
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
Desc
25.0.1.5           4  65010      526      538      5         0     0   01:40:52         11

Total number of neighbors 1

Total number of Established sessions 1

BGP VRF vrf2000 Route Distinguisher: 10:2000
BGP table version is 2
3 BGP AS-PATH entries
0 BGP community entries

Neighbor          V    AS      MsgRcv   MsgSen  TblVer   InQ   OutQ   Up/Down   State/PfxRcd
Desc
100.1.1.2          4   100       41       49      2         0     0   00:15:47         10

Total number of neighbors 1

Total number of Established sessions 1
RTR1#show ip bgp vpnv4 all
Status codes: s suppressed, d damped, h history, a add-path, b back-up, * valid, > best, i -
internal, l - labeled
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

      Network          Next Hop           Metric    LocPrf    Weight Path
Route Distinguisher: 10:2000 (Default for VRF vrf2000)
*> 1 100.1.1.0/24      0.0.0.0             0         100      32768 ?      -
*> 1 101.0.0.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.1.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.2.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.3.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.4.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.5.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.6.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.7.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.8.0/24      100.1.1.2           0         100      0 100 i      -
*> 1 101.0.9.0/24      100.1.1.2           0         100      0 100 i      -
*>i 200.1.1.0          25.0.1.3            0         100      0 ?          2000
*>i 201.0.0.0          25.0.1.3            0         100      0 200 i      2000
*>i 201.0.1.0          25.0.1.3            0         100      0 200 i      2000

```

```

*>i 201.0.2.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.3.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.4.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.5.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.6.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.7.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.8.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.9.0      25.0.1.3      0      100      0      200 i      2000
  Announced routes count = 11
  Accepted routes count = 11
Route Distinguisher: 10:2000
*>i 200.1.1.0      25.0.1.3      0      100      0      ?      2000
*>i 201.0.0.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.1.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.2.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.3.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.4.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.5.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.6.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.7.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.8.0      25.0.1.3      0      100      0      200 i      2000
*>i 201.0.9.0      25.0.1.3      0      100      0      200 i      2000
  Announced routes count = 0
  Accepted routes count = 11

RTR1#show ip route vrf vrf2000
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 "vrf2000"
C      100.1.1.0/24 is directly connected, xe15.2000, installed 00:35:21, last update
00:35:21 ago
B      101.0.0.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.1.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.2.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.3.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.4.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.5.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.6.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.7.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.8.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
B      101.0.9.0/24 [20/0] via 100.1.1.2, xe15.2000, installed 00:16:14, last update
00:16:14 ago
C      127.0.0.0/8 is directly connected, lo.vrf2000, installed 01:38:23, last update
01:38:23 ago

Gateway of last resort is not set

```

Ensure that MPLS label switching follows the path determined by FlexAlgo and ODN.

```

RTR1#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
 Ext-Color - Extended-community color advertised by BGP

Code Intf	FEC Nexthop	FTN-ID UpTime	VRF-ID Ext-Color	Nhlfe-ID	Pri	Out-Label	Out-
B>	200.1.1.0/24 25.0.1.3	1 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.0.0/24 25.0.1.3	2 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.1.0/24 25.0.1.3	3 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.2.0/24 25.0.1.3	4 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.3.0/24 25.0.1.3	5 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.4.0/24 25.0.1.3	6 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.5.0/24 25.0.1.3	7 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.6.0/24 25.0.1.3	8 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.7.0/24 25.0.1.3	9 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.8.0/24 25.0.1.3	10 00:06:36	2 2000	4	Yes	81344	-
B>	201.0.9.0/24 25.0.1.3	11 00:06:36	2 2000	4	Yes	81344	-

RTR1#

RTR1#show mpls dep-up table

=====

Route-Node Prefix: 25.0.1.3

=====

CLIST-INFO:

c_list-Pointer = 30b33e0
 c_list-Type = CONFIRM_NODE_FTN
 c_list-Prefix = 25.0.1.3/32
 c_list-Count = 12

CONFIRM-NODE INFO:

Confirm-Node-Pointer = f4627060
 Confirm-Data-Pointer = ec5d4400
 Confirm-Node-Type = CONFIRM_VRF
 Fec-Prefix = 201.0.0.0/24
 Color = 2000
 Parent-FTN-Pointer = ec5d2040
 Parent-FTN-Index = 6
 Parent-FTN-Name = N/A
 Parent-FTN-Owner = ISIS-SR-FA
 Parent-FTN-Algo-Num = 128

CONFIRM-NODE INFO:

Confirm-Node-Pointer = f4627090
 Confirm-Data-Pointer = ec5d4740
 Confirm-Node-Type = CONFIRM_VRF
 Fec-Prefix = 201.0.1.0/24
 Color = 2000
 Parent-FTN-Pointer = ec5d2040
 Parent-FTN-Index = 6
 Parent-FTN-Name = N/A
 Parent-FTN-Owner = ISIS-SR-FA
 Parent-FTN-Algo-Num = 128

CONFIRM-NODE INFO:

Confirm-Node-Pointer = f46270c0
 Confirm-Data-Pointer = ec5d4a80
 Confirm-Node-Type = CONFIRM_VRF
 Fec-Prefix = 201.0.2.0/24
 Color = 2000
 Parent-FTN-Pointer = ec5d2040

```

    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f46270f0
    Confirm-Data-Pointer  = ec5d4dc0
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 201.0.3.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f4627120
    Confirm-Data-Pointer  = ec5d5100
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 201.0.4.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f4627150
    Confirm-Data-Pointer  = ec5d5440
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 201.0.5.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f4627180
    Confirm-Data-Pointer  = ec5d5780
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 201.0.6.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f46271b0
    Confirm-Data-Pointer  = ec5d5ac0
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 201.0.7.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f46271e0
    Confirm-Data-Pointer  = ec5d5e00
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 201.0.8.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A

```

```

    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f4627210
    Confirm-Data-Pointer  = ec5d6140
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 201.0.9.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128
CONFIRM-NODE INFO:
    Confirm-Node-Pointer  = f4627030
    Confirm-Data-Pointer  = ec5d40c0
    Confirm-Node-Type     = CONFIRM_VRF
    Fec-Prefix            = 200.1.1.0/24
    Color                 = 2000
    Parent-FTN-Pointer    = ec5d2040
    Parent-FTN-Index      = 6
    Parent-FTN-Name       = N/A
    Parent-FTN-Owner      = ISIS-SR-FA
    Parent-FTN-Algo-Num   = 128

RTR1#show mpls forwarding-table 25.0.1.3/32 algorithm 128
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          NextHop   FTN-ID   Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC             Algo-Num
UpTime
i>    25.0.1.3/32      6         61       -         -         (e)   -         -         -
      -              128        03:52:48
      11.0.12.2       -         -         22       0         Yes   21283     ge2        No
      11.0.15.5       -         -         60       0         Yes   21283     ge6        No

RTR1#show mpls ftn-table 25.0.1.3/32 algorithm 128
Primary FTN entry with FEC: 25.0.1.3/32, id: 6, row status: Active, Tunnel-Policy: N/A, State:
Installed
CreateTime: 03:52:56, UpTime: 03:52:56, LastUpdate: N/A
Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none,
Algorithm Number:128
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 22 refcount: 1
Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
Out-segment with ix: 22, owner: ISIS-SR-FA, Stale: NO, refcount: 4, out intf: ge2, out
label: 21283
NextHop addr: 11.0.12.2          cross connect ix: 8, op code: Push

Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 60 refcount: 1
Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
Out-segment with ix: 60, owner: ISIS-SR-FA, Stale: NO, refcount: 2, out intf: ge6, out
label: 21283
NextHop addr: 11.0.15.5          cross connect ix: 8, op code: Push

Dependent service info (count 12):
[CONFIRM_VRF] ftn_ix 6 owner BGP prefix 201.0.4.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000

```



```
[CONFIRM_VRF] ftn_ix 3 owner BGP prefix 201.0.1.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 1 owner BGP prefix 200.1.1.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 2 owner BGP prefix 201.0.0.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 4 owner BGP prefix 201.0.2.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 5 owner BGP prefix 201.0.3.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 9 owner BGP prefix 201.0.7.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 7 owner BGP prefix 201.0.5.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 8 owner BGP prefix 201.0.6.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 10 owner BGP prefix 201.0.8.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
[CONFIRM_VRF] ftn_ix 11 owner BGP prefix 201.0.9.0/24 nhlfe_ix 4 vrf 2 Ext-Color 2000
```

Configuration for EVPN Traffic Steering with ODN for FlexAlgo

The following configuration enables EVPN-ELINE Traffic Steering with an ODN Policy:

- This setup extends the existing configuration from the section to support EVPN ELINE services over Flex-Algo 129.
- The ODN policy dynamically steers EVPN ELINE traffic, ensuring that it follows the most optimal paths based on the constraints and metrics defined for Flex-Algo 129.
- This approach facilitates the seamless integration of EVPN ELINE over an SR-based network, enhancing traffic engineering flexibility while optimizing resource utilization.

1. Configure BGP On RTR1 and RTR3 which are PE routers and RTR5(RR).

a. Set up BGP in Address-Family L2VPN EVPN on RTR1 and RTR2 as below.

```
RTR1(config)#router bgp 65010
RTR1(config-router)# bgp auto-policy-soft-reset enable
RTR1(config-router)# neighbor 25.0.1.5 remote-as 65010
RTR1(config-router)# neighbor 25.0.1.5 update-source loopback2
RTR1(config-router)# end
RTR1(config-router)# address-family l2vpn evpn
RTR1(config-router-af)# neighbor 25.0.1.5 activate
RTR1(config-router-af)# exit-address-family
RTR1(config-router)# end
RTR1(config-router)# exit
```

```
RTR3(config)#router bgp 65010
RTR3(config-router)# bgp auto-policy-soft-reset enable
RTR3(config-router)# neighbor 25.0.1.5 remote-as 65010
RTR3(config-router)# neighbor 25.0.1.5 update-source loopback2
RTR3(config-router)# end
RTR3(config-router)# address-family l2vpn evpn
RTR3(config-router-af)# neighbor 25.0.1.5 activate
RTR3(config-router-af)# exit-address-family
RTR3(config-router)# end
RTR3(config-router)# exit
```

b. Set up BGP in Address-Family L2VPN EVPN on RTR5 which acts as RR below:

```
RTR5(config)#router bgp 65010
RTR5(config-router)# bgp auto-policy-soft-reset enable
RTR5(config-router)# no bgp inbound-route-filter
RTR5(config-router)# neighbor 25.0.1.1 remote-as 65010
RTR5(config-router)# neighbor 25.0.1.1 update-source loopback2
RTR5(config-router)# neighbor 25.0.1.3 remote-as 65010
RTR5(config-router)# neighbor 25.0.1.3 update-source loopback2
RTR5(config-router)# !
RTR5(config-router)# address-family l2vpn evpn
RTR5(config-router-af)# neighbor 25.0.1.1 activate
```

```
RTR5(config-router-af)# neighbor 25.0.1.1 route-reflector-client
RTR5(config-router-af)# neighbor 25.0.1.3 activate
RTR5(config-router-af)# neighbor 25.0.1.3 route-reflector-client
RTR5(config-router-af)# exit-address-family
RTR5(config-router)# !
RTR5(config-router)# exit
```

2. Configure MAC-VRF on PE Routers (RTR1 and RTR3):

```
RTR1(config)#mac vrf ELINE_SH
RTR1(config-vrf)# rd 25.0.1.1:3000
RTR1(config-vrf)#route-target both evpn-auto-rt

RTR3(config)#mac vrf ELINE_SH
RTR3(config-vrf)# rd 25.0.1.3:3000
RTR3(config-vrf)#route-target both evpn-auto-rt
```

3. Configure EVPN ELINE instance:

```
RTR1(config)#evpn mpls enable
RTR1(config)#evpn mpls vtep-ip-global 25.0.1.1
RTR1(config)#!
RTR1(config)#evpn mpls id 3000 xconnect target-mpls-id 3001
RTR1(config-evpn-mpls)# host-reachability-protocol evpn-bgp ELINE_SH
RTR1(config-evpn-mpls)#!

RTR3(config)#evpn mpls enable
RTR3(config)#evpn mpls vtep-ip-global 25.0.1.3
RTR3(config)#!
RTR3(config)#evpn mpls id 3001 xconnect target-mpls-id 3000
RTR3(config-evpn-mpls)# host-reachability-protocol evpn-bgp ELINE_SH
RTR3(config-evpn-mpls)#!
```

4. Configure the egress side to advertise the color per VRF under address-family using a route-map.

```
RTR3(config)#
RTR3(config)#route-map set_color_ELINE3000 permit 10
RTR3(config-route-map)#set extcommunity color 3000
RTR3(config-if)#exit

RTR3(config)#evpn mpls id 3001 xconnect target-mpls-id 3000
RTR3(config-evpn-mpls)# route-map set_color_ELINE3000
RTR3(config-evpn-mpls)#end
```

5. Enable ODN Policy for Traffic Steering on RTR1 for EVPN routes coming from RTR3

```
RTR1(config)#
RTR1(config)#segment-routing
RTR1(config-sr)# traffic-engineering
RTR1(config-sr-te)# on-demand-nexthop 3000
RTR1(config-sr-odn)# flex-algo 129
RTR1(config-sr-odn)# exit-sr-odn
RTR1(config-sr-te)# end
RTR1(config-sr-te)# exit-te
RTR1(config-sr)#commit
```

Configuration Snapshot

RTR1

Configuration Snapshot RTR1

```
router bgp 65010
bgp auto-policy-soft-reset enable
```

```
neighbor 25.0.1.5 remote-as 65010
neighbor 25.0.1.5 update-source loopback2
!
address-family l2vpn evpn
  neighbor 25.0.1.5 activate
  exit-address-family
!
exit

mac vrf ELINE_SH
  rd 25.0.1.1:3000
  route-target both evpn-auto-rt

evpn mpls enable

evpn mpls vtep-ip-global 25.0.1.1
!
evpn mpls id 3000 xconnect target-mpls-id 3001
  host-reachability-protocol evpn-bgp ELINE_SH
!
interface xe15
  mtu 9216
!
interface xe15.3000 switchport
  encapsulation dot1q 3000
  access-if-evpn
  map vpn-id 3000
```

RTR3

Configuration Snapshot RTR3

```
router bgp 65010
  bgp auto-policy-soft-reset enable
  neighbor 25.0.1.5 remote-as 65010
  neighbor 25.0.1.5 update-source loopback2
!
address-family l2vpn evpn
  neighbor 25.0.1.5 activate
  exit-address-family
!
!
exit

mac vrf ELINE_SH
  rd 25.0.1.3:3000
  route-target both evpn-auto-rt

evpn mpls enable

evpn mpls vtep-ip-global 25.0.1.3
!
evpn mpls id 3001 xconnect target-mpls-id 3000
  host-reachability-protocol evpn-bgp ELINE_SH
!
interface xe19
  mtu 9216
!
interface xe19.3000 switchport
  encapsulation dot1q 3000
  mtu 9216
  access-if-evpn
  map vpn-id 3001

route-map set_color_ELINE3000 permit 10
  set extcommunity color 3000
```

```

exit

evpn mpls id 3001 xconnect target-mpls-id 3000
route-map set_color_ELINE3000

```

RTR5

Configuration Snapshot RTR5

```

router bgp 65010
  bgp auto-policy-soft-reset enable
  no bgp inbound-route-filter
  neighbor 25.0.1.1 remote-as 65010
  neighbor 25.0.1.1 update-source loopback2
  neighbor 25.0.1.3 remote-as 65010
  neighbor 25.0.1.3 update-source loopback2
  !
  address-family l2vpn evpn
  neighbor 25.0.1.1 activate
  neighbor 25.0.1.1 route-reflector-client
  neighbor 25.0.1.3 activate
  neighbor 25.0.1.3 route-reflector-client
  exit-address-family
  !
exit

```

Validation

Verify BGP EVPN neighbor state and received prefixes:

```

RTR1#show bgp l2vpn evpn summary
BGP router identifier 25.0.1.1, local AS number 65010
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
AD  MACIP
MCAST  ESI PREFIX-ROUTE Desc
25.0.1.5      4
65010      123      113      8        0        0  00:44:41      1        1        0        0
0          0

Total number of neighbors 1

Total number of Established sessions 1
RTR1#sh bgp l2vpn evpn
BGP table version is 8, local router ID is 25.0.1.1
Status codes: s suppressed, d damped, h history, a add-path, b back-up, * valid, > best, i -
internal,
               1 - labeled, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
Description : Ext-Color - Extended community color

[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[25.0.1.1:3000] VRF[ELINE_SH]:
*> [1]:[0]:[3000]:[81920]
      25.0.1.1          0          100          32768 i          - -----
      MPLS
* i [1]:[0]:[3001]:[81280]
      25.0.1.3          0          100          0 i          3000 25.0.1.5
      MPLS

RD[25.0.1.3:3000]
*>i [1]:[0]:[3001]:[81280]
      25.0.1.3          0          100          0 i          3000 25.0.1.5
      MPLS

```

Verify dependency resolution for EVPN service steering over FlexAlgo:

```

RTR1#show mpls dep-up table
=====
Route-Node Prefix: 25.0.1.3
=====
CLIST-INFO:
  c_list-Pointer = 27d34d0
  c_list-Type    = CONFIRM_NODE_FTN
  c_list-Prefix  = 25.0.1.3/32
  c_list-Count   = 1
-----
CONFIRM-NODE INFO:
  Confirm-Node-Pointer = b6402210
  Confirm-Data-Pointer = 27d3e30
  Confirm-Node-Type    = CONFIRM_EVPN
  EVPN-ID              = 3000
  Destination Peer     = 25.0.1.3
  Color                = 3000
  Parent-FTN-Pointer   = ae7c0700
  Parent-FTN-Index     = 13
  Parent-FTN-Name      = N/A
  Parent-FTN-Owner     = ISIS-SR-FA
  Parent-FTN-Algo-Num  = 129
Verify EVPN MPLS tunnel lab

```

Verify el allocation and underlay path:

```

RTR1#show evpn mpls xconnect tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      local-evpn-id
remote-evpn-id
=====
25.0.1.1    25.0.1.3            Installed   00:05:12    00:05:12    3000         3001

Total number of entries are 1

```

Verify EVPN MPLS tunnel label allocation and underlay path:

```

RTR1#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
=====+=====+=====+=====+=====+=====+=====
Multipath      Underlay      Local      Remote      Local      Remote      MPLS-
Destination    Status      VPWS-ID    VPWS-ID    Policy      UC-Label    UC-Label    Grp-
Name           NHLFE-ix
NW-Intf        NW-Label
=====+=====+=====+=====+=====+=====+=====
25.0.1.3       Installed   3000       3001       --          81920       81280       --
57             ge2        21293

```

Total number of entries are 1

Verify EVPN cross-connect status and MTU configuration:

```
RTR1#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				
3000	25.0.1.3	9216	3001	xe15.3000	--- Single Homed Port ---		
		AC-NW	NW-SET				

Total number of entries are 1

Verify FlexAlgo FTN entry and corresponding LSP information:

```
RTR1#show mpls ftn-table 25.0.1.3/32 algorithm 129
Primary FTN entry with FEC: 25.0.1.3/32, id: 13, row status: Active, Tunnel-Policy: N/A, State:
Installed
CreateTime: 00:45:21, UpTime: 00:45:21, LastUpdate: N/A
Owner: ISIS-SR-FA, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none,
Algorithm Number:129
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: 56 refcount: 1
Owner: ISIS-SR-FA, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
Out-segment with ix: 56, owner: ISIS-SR-FA, Stale: NO, refcount: 2, out intf: ge2, out
label: 21293
Nexthop addr: 11.0.12.2          cross connect ix: 7, op code: Push
```

SR Policy Hop-Limit

The Segment Routing (SR) Policy Hop-Limit feature introduces an additional constraint to SR policies, allowing users to specify the maximum number of hops a packet can traverse within a defined SR policy path. This ensures that traffic follows an optimized path and prevents potential routing loops.

SR Policy is an ordered list of segments (instructions) representing a source-routed path. The headend node steers traffic into the SR Policy, embedding the ordered segment list into the packet header.

The Hop-Limit parameter acts as a constraint in dynamic path computation, restricting the path length in terms of the number of hops between the source and destination.

Feature Characteristics

- Allows configuration of a maximum hop count for dynamic SR Policy paths.
- Applicable to dynamic candidate paths computed via:
 - IS-IS
 - OSPF
 - Path Computation Element Protocol (PCEP)
- Prevents long routing paths and looping behavior.
- No default hop-limit value is configured.
- Supports both SR Policy and SR ODN Policy types.

Benefits

This feature offers several key advantages:

- Loop Prevention: Restricts packets from traversing excessive hops, mitigating looping scenarios.
- Optimized Path Selection: Ensures that only efficient routes within the defined hop count are selected.
- Improved Stability: Minimizes route instability in networks with multiple path options.
- Operational Flexibility: Provides an additional control parameter to fine-tune SR Policy computations.

Prerequisites

This feature requires the following device capabilities:

- SR-MPLS must be enabled in the network.
- Underlay IGP (IS-IS or OSPF) must be configured and operational.
- All nodes participating in SR Policy computation must advertise Prefix-SIDs.

Limitations

- The maximum SID depth supported in Qumran (Q1 and Q2) series platforms is 6.
- Although the maximum supported hop-limit value is 32, the SR Policy will not become active if the actual number of hops exceeds 6.

- Explicit policy does not support hop limit.

Configuration

The following configuration enables SR with a Hop-Limit constraint under a dynamic SR Policy between PE1 (headend) and PE2 (endpoint).



Note: When OSPF is configured with the network point-to-point type as the IGP, CSPF computation with a hop-limit constraint may not always select the optimal cost path, particularly when the source node has a direct connection to the egress node.

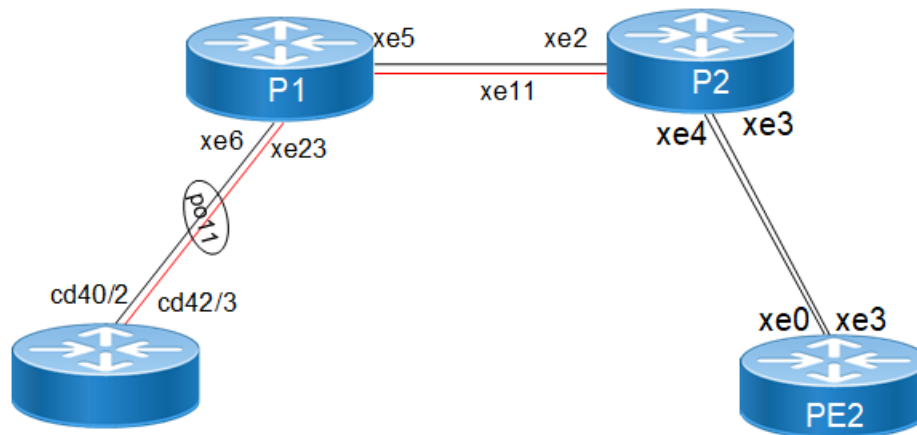
Topology

This topology represents the four-node MPLS Segment Routing topology consisting of two Provider Edge (PE) routers and two core Provider (P) routers interconnected in a linear sequence.

The headend node (PE1) establishes an SR Policy towards the endpoint node (PE2). Both nodes participate in an IS-IS domain that provides the underlay for Segment Routing. All interfaces are configured with MPLS label switching and enabled for both IS-IS and OSPF to support SR label advertisement and path computation.

In this setup, PE1 acts as the headend node, responsible for initiating and maintaining the SR Policy with a defined hop-limit constraint. The intermediate nodes (P1 and P2) function as SR transit nodes that forward labeled packets based on MPLS and SR labels. The endpoint node (PE2) is the destination for traffic steered through the SR Policy.

Figure 15. SR Policy Hop-limit



Perform the following configurations:

1. Configure Loopback and Assign Prefix-SID to define the router ID and Prefix-SID for SR operations.

```

PE1(config)# interface lo
PE1(config-if)# ip address 127.0.0.1/8
PE1(config-if)# ip address 2.2.2.2/32 secondary
PE1(config-if)# prefix-sid index 2 no-php
PE1(config-if)# ip router isis 1
PE1(config-if)# exit

```



Notes: Repeat similar configuration on all routers (P1, P2, PE2) with unique loopback and Prefix-SID values:

- P1 → 28.28.28.28 / Prefix-SID 28
- P2 → 29.29.29.29 / Prefix-SID 29
- PE2 → 18.18.18.18 / Prefix-SID 18

2. Configure Physical Links to establish point-to-point connectivity and enable MPLS label switching.

```
PE1(config)# interface poll
PE1(config-if)# load-interval 30
PE1(config-if)# ip address 11.1.1.1/30
PE1(config-if)# mtu 9216
PE1(config-if)# label-switching
PE1(config-if)# isis network point-to-point
PE1(config-if)# ip router isis 1
PE1(config-if)# exit
```



Notes: Repeat similar configuration on all routers (P1, P2, PE2) with unique loopback and Prefix-SID values:

- P1–P2 (16.1.1.1/30 – 16.1.1.2/30)
- P2–PE2 (18.1.1.2/30 – 18.1.1.1/30)

3. Enable IS-IS as the IGP for SR, define router IDs, and allocate SRGB (Segment Routing Global Block).

```
PE1(config)# router isis 1
PE1(config-router)# is-type level-2-only
PE1(config-router)# spf-interval-exp 1 1
PE1(config-router)# metric-style wide
PE1(config-router)# mpls traffic-eng router-id 2.2.2.2
PE1(config-router)# mpls traffic-eng level-2
PE1(config-router)# capability cspf
PE1(config-router)# dynamic-hostname
PE1(config-router)# bfd all-interfaces
PE1(config-router)# net 49.0001.0000.0001.0002.00
PE1(config-router)# isis segment-routing global block 20000 23999
PE1(config-router)# segment-routing mpls
PE1(config-router)# exit
```



Note: Repeat this configuration on all nodes with unique router IDs and NET addresses.

4. Configure the SR hop limit.

```
PE1(config)# segment-routing
PE1(config-sr)# traffic-engineering
PE1(config-sr-te)# policy 1
PE1(config-sr-pol)# color 1 end-point 18.18.18.18
PE1(config-sr-pol)# candidate-path 1
PE1(config-sr-pol-cp)# dynamic-path isis 1
PE1(config-sr-pol-cp)# constraints
PE1(config-sr-dyn-cp-cons)# hop-limit 3
PE1(config-sr-dyn-cp-cons)# exit-cp-cons
PE1(config-sr-pol-cp)# exit-pol-cp
PE1(config-sr-pol)# exit-sr-pol
PE1(config-sr-te)# exit-te
PE1(config-sr)# exit
```

Validation

Verify the configured hop-limit value under SR policy attributes:

```
PE1#show segment-routing policy

Policy-Name          Color      End-
point              State      Forwarding-Info
1                    1          18.18.18.18      UP
3/24961/24965/poll
PE1#show segment-routing policy detail

Policy-Name: 1      Color 1      End-point 18.18.18.18      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:01:14
State Transition Count: 3
CSPF Retry Limit: 100      CSPF Retry Interval: 10
Binding SID :
BSID: 26240
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 100      Path Type: Dynamic(isis)      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 3
Segment0[LABEL]: Label :26880
Segment1[LABEL]: Label :24961
Segment2[LABEL]: Label :24965
Out-if: poll      Out-label-stack: 3/24961/24965
Computed TE Metric: 30
Hop-Count: 3
Attributes:
Configured:
SID-Algorithm: 0
Affinity:
Metric-type: TE
IP Constraints:
Hop-Limit: 3
```

Verify the operational hop-limit applied to the computed LSP.

```
PE1#show cspf lsp
LSP detail
SR-Algorithm          : SPF
Trunk ID              : 1
LSP ID                : 1
ISIS Tag Name         : 1
Client ID             : 0
State                 : Established(3)
Egress                : 18.18.18.18
Ext Tunnel ID         : 18.18.18.18
LSP Type              : 0
Hop Limit             : 3
Retry Interval        : 10
Retry Timer           : OFF
Retry Limit           : 100
Remaining Retry Count : 0
LSP Metric            : 30
Computed ERO          :
11.1.1.2
16.1.1.2
24.1.1.2
```

Verify whether policy installed in ftn or not.

```
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, SR: Enabled
```

Code	FEC	FTN-ID	Nhlife-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
P>	18.18.18.18/32	5	105	1	Yes	3	poll Yes
11.1.1.2	N/A	00:01:38					
i>	18.18.18.18/32	9	90	-	-	-	-
	-	0	00:01:39				
			89	0	Yes	20018	poll Yes
11.1.1.2	-	-					
i>	28.28.28.28/32	1	60	-	-	-	-
	-	0	15:27:27				
			34	0	Yes	20028	poll Yes
11.1.1.2	-	-					
i>	29.29.29.29/32	2	87	-	-	-	-
	-	0	15:27:27				
			37	0	Yes	20029	poll Yes
11.1.1.2	-	-					
B>	181::/64	15	152	0	Yes	28874	-
	No	18.18.18.18	N/A	00:01:39			
B>	182::/64	44	152	0	Yes	28874	-
	No	18.18.18.18	N/A	00:01:39			
B>	183::/64	45	152	0	Yes	28874	-
	No	18.18.18.18	N/A	00:01:39			
B>	184::/64	46	152	0	Yes	28874	-
	No	18.18.18.18	N/A	00:01:39			
B>	185::/64	48	152	0	Yes	28874	-
	No	18.18.18.18	N/A	00:01:39			

Implementation Examples

- Path Constrained Traffic Engineering: When an operator wants to restrict SR policy computation within a specific number of hops (for example, 3 hops) to ensure traffic only traverses within a given metro or regional network segment.
- Inter-Datacenter Connectivity Control: Used to limit SR paths between datacenters so that policies do not traverse beyond a fixed number of intermediate routers, maintaining control over inter-DC paths.

Glossary

Term	Description
Hop-Limit	A configuration parameter that defines the maximum number of hops (intermediate nodes) an SR policy can traverse during path computation. If the computed path exceeds this limit, it is not programmed.
Candidate Path (CP)	A potential path for an SR policy, which can be dynamically computed or explicitly configured. The active CP determines the operational path of the policy.
Constrained Shortest Path First (CSPF)	A path computation algorithm that finds the shortest path between nodes while satisfying specific constraints (like bandwidth, hop-limit, or affinity).
Binding Segment ID (BSID)	A label that represents an SR policy, allowing other nodes or services to use the policy as a segment in their own SR paths.
Explicit Route Object (ERO)	A list of IP addresses or labels representing the explicit path that packets must follow from source to destination.
Label Switched Path (LSP)	A unidirectional logical path through an MPLS or SR network, identified by a sequence of labels used for forwarding packets.

Configuring ISIS SR Mapping Server with LDP

This section shows how to configure ISIS segment routing mapping server to work with LDP.

A segment routing mapping server allocates Segment Identifiers (SIDs) for prefixes and ranges of prefixes in an ISIS segment routing domain. LDP can advertise SIDs for destinations in the LDP part of the network that does not support segment routing. These segments are converted to MPLS labels and installed in the FTN/ILM and forwarding tables.

ISIS uses ISIS-TE TLVs to advertise any additional attributes associated with a prefix by adding new TLVs or sub-TLVs to the existing ISIS-TE TLVs.

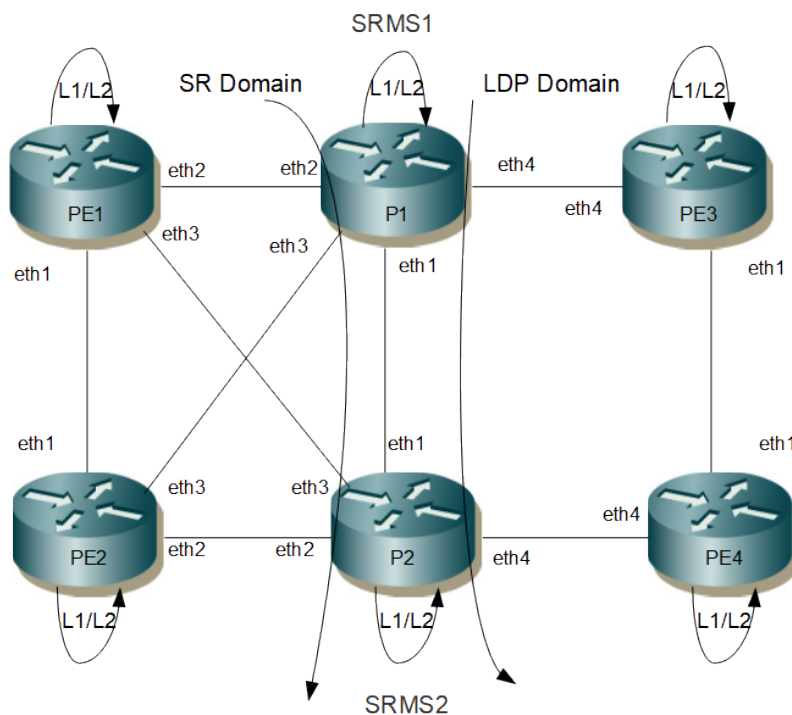


Note: Configure an ISIS Level-1/Level-2 router as a mapping server, as it propagates both Level-1 and Level-2 LSPs.

Topology

- “L1” means ISIS routers in Level-1
- “L2” means ISIS routers in Level-2
- “L1/L2” means ISIS routers in both Level-1 and Level-2

Figure 16. ISIS Segment routing with mapping server and LDP



- PE1 to PE2 are in a Segment routing domain.
- P1 and P2 are in both Segment routing and LDP domain.
- PE3 and PE4 are in LDP domain.

- P1 and P2 are SR/LDP nodes both acting as SRMS nodes.

Configurations

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 10.0.1.11/32 secondary	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#prefix-sid index 100	Configure prefix sid index value.
PE1 (config-if)#exit	Exit interface mode.
PE1(config)#interface eth2	Enter interface mode.
PE1(config-if)#ip address 10.11.1.1/30	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth3	Enter interface mode.
PE1(config-if)#ip address 10.11.2.1/30	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.
PE1(config-if)#ip address 10.11.22.1/30	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router isis isis1	Set the routing process ID.
PE1(config-router)#metric-style wide	Configure metric style as wide.
PE1(config-router)#is-type level-1-2	Configure is-type with level-1-2.

PE1(config-router)#net 49.0000.0100.0000.1011.00	Configure Network entity title (NET).
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-1.
PE1(config-router)# dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
PE1(config-router)# isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
PE1(config-router)#segment-routing mpls	Enable segment routing under router process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)# ip address 10.0.1.22/32 secondary	Configure the IP address of the interface.
PE2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE2(config-if)#prefix-sid index 700	Configure prefix sid index value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth1	Enter interface mode.
PE2(config-if)#ip address 10.11.22.2/30	Configure the IP address of the interface.
PE2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth3	Enter interface mode.
PE2(config-if)#ip address 10.22.1.1/30	Configure the IP address of the interface.
PE2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.

PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth2	Enter interface mode.
PE2(config-if)#ip address 10.22.2.1/30	Configure the IP address of the interface.
PE2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router isis isis1	Set the routing process ID
PE2(config-router)#metric-style wide	Configure metric style as wide.
PE2(config-router)#is-type level-1-2	Configure is-type with level-1-2.
PE2(config-router)#net 49.0000.0100.0000.1022.00	Configure Network entity title (NET).
PE2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2 as well.
PE2(config-router)# isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
PE2(config-router)#segment-routing mpls	Enable segment routing under router process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration.

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#router ldp	Enter router ldp mode.
P1(config-router)#exit	Exit router mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)# ip address 10.0.1.1/32 secondary	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.

P1(config-if)#prefix-sid index 200	Configure prefix sid index value.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth2	Enter interface mode.
P1(config-if)#ip address 10.11.1.2/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth3	Enter interface mode.
P1(config-if)#ip address 10.22.1.2/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth1	Enter interface mode.
P1(config-if)#ip address 10.1.2.1/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#enable-ldp ipv4	Enable ldp ipv4 under the interface.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth4	Enter interface mode.
P1(config-if)#ip address 10.33.1.2/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#enable-ldp ipv4	Enable ldp ipv4 under the interface.
P1(config-if)#exit	Exit interface mode.
P1(config)#router isis isis1	Set the routing process ID
P1(config-router)#metric-style wide	Configure metric style as wide.
P1(config-router)#is-type level-1-2	Configure is-type with level-1-2.
P1(config-router)#net 49.0000.0100.0000.1001.00	Configure Network entity title (NET).
P1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.

P1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2 as well.
P1(config-router)# isis segment-routing global block 17000 23500	Enable SRGB under ISIS isis1 process.
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)# segment-routing prefix-sid-map advertise-local	Enable segment routing prefix-sid-map advertise-local under router process.
P1(config-router)#exit	Exit router mode.
P1(config)#segment-routing	Enable segment routing global mode
P1(config-sr)#mapping-server	Enter segment routing mapping server configuration mode.
P1(config-sr-ms)#srms preference 200	Configure segment routing mapping server preference value.
P1(config-sr-ms)#prefix-sid-map address-family ipv4	Enter prefix-SID mapping configuration mode.
P1(config-sr-ms-map-af4)#10.0.1.33/32 1111 range 1	Configure mapping server entry for PE3 assigning sids to prefixes.
P1(config-sr-ms-map-af4)#10.0.1.44/32 1555 range 1	Configure mapping server entry for PE4 assigning sids to prefixes.
P1(config-sr-ms-map-af4)#exit	Exit to privileged mode.
P1(config)#mpls lsp-stitching	Stitch segment routing with LDP.
P1(config)#commit	Commit the candidate configuration to the running configuration.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#router ldp	Enter router ldp mode.
P2(config-router)#exit	Exit router mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 10.0.1.2/32 secondary	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)# prefix-sid index 300 no-php	Configure prefix sid index value with no php.

P2 (config-if) #exit	Exit interface mode.
P2 (config) #interface eth3	Enter interface mode.
P2 (config-if) #ip address 10.11.2.2/30	Configure the IP address of the interface.
P2 (config-if) #ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2 (config-if) #label-switching	Enable label switching.
P2 (config-if) #exit	Exit interface mode.
P2 (config) #interface eth1	Enter interface mode.
P2 (config-if) #ip address 10.1.2.2/30	Configure the IP address of the interface.
P2 (config-if) #ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2 (config-if) #label-switching	Enable label switching.
P2 (config-if) #enable-ldp ipv4	Enable ldp ipv4 under the interface.
P2 (config-if) #exit	Exit interface mode.
P2 (config) #interface eth2	Enter interface mode.
P2 (config-if) #ip address 10.22.2.2/30	Configure the IP address of the interface.
P2 (config-if) #ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2 (config-if) #label-switching	Enable label switching.
P2 (config-if) #exit	Exit interface mode.
P2 (config) #interface eth4	Enter interface mode.
P2 (config-if) #ip address 10.44.2.2/30	Configure the IP address of the interface.
P2 (config-if) #ip router isis isis1	Make the interface part of the router isis 1 instance.
P2 (config-if) #label-switching	Enable label switching.
P2 (config-if) #enable-ldp ipv4	Enable ldp ipv4 under the interface.
P2 (config-if) #exit	Exit interface mode.
P2 (config) #router isis isis1	Set the routing process ID .
P2 (config-router) #metric-style wide	Configure metric style as wide.
P2 (config-router) #is-type level-1-2	Configure is-type.
P2 (config-router) #net 49.0000.0100.0000.1002.00	Configure Network entity title (NET).
P2 (config-router) #mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P2 (config-router) #mpls traffic-eng	Enable MPLS Traffic Engineering as level-2 as

level-2	well.
P2 (config-router) #dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
P2(config-router)isis segment-routing global block 16500 22500	Enable SRGB under ISIS isis1 process.
P2(config-router) #segment-routing mpls	Enable segment routing under router process.
P2(config-router) #exit	Exit router mode.
P2(config) #segment-routing	Enter segment routing global mode.
P2(config-sr) # mapping-server	Enter segment routing mapping server configuration mode.
P2(config-sr-ms) #srms preference 100	Configure segment routing mapping server preference value.
P2(config-sr-ms) #prefix-sid-map address-family ipv4	Enter prefix-SID mapping configuration mode.
P2(config-sr-ms-map-af4) #10.0.1.33/32 2111 range 1	Configure mapping server entry for PE3 assigning sids to prefixes.
P2(config-sr-ms-map-af4) #10.0.1.44/32 2511 range 1	Configure mapping server entry for PE4 assigning sids to prefixes.
P2(config-sr-ms-map-af4) #exit	Exit to privileged mode.
P2(config) #mpls lsp-stitching	Stitch segment routing with LDP.
P2(config) #commit	Commit the candidate configuration to the running configuration.

PE3

The following are the step-by-step configurations on the PE3 router.

PE3(config) #interface lo	Enter interface mode.
PE3(config-if) #ip address 10.0.1.33/32 secondary	Configure the IP address of the interface.
PE3(config-if) #ip router isis isis1	Make the interface part of the router isis 1 instance.
PE3(config-if) #exit	Exit interface mode.
PE3(config) #router ldp	Enter router ldp mode.
PE3(config-router) #exit	Exit router mode.
PE3(config) #interface eth1	Enter interface mode.

PE3(config-if)#ip address 10.33.44.1/30	Configure the IP address of the interface.
PE3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE3(config-if)#label-switching	Enable label switching.
PE3(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface.
PE3(config-if)#exit	Exit interface mode.
PE3(config)#interface eth4	Enter interface mode.
PE3 (config-if)#ip address 10.33.1.1/30	Configure the IP address of the interface.
PE3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE3(config-if)#label-switching	Enable label switching.
PE3(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface.
PE3(config-if)#exit	Exit interface mode.
PE3(config)#router isis isis1	Set the routing process ID.
PE3(config-router)#metric-style wide	Configure metric style as wide.
PE3(config-router)#is-type level-1-2	Configure is-type.
PE3(config-router)#net 49.0000.0100.0000.1033.00	Configure Network entity title (NET).
PE3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE3(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE3(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process
PE3(config-router)#exit	Exit router mode.
PE3(config)#commit	Commit the candidate configuration to the running configuration.

PE4

The following are the step-by-step configurations on the PE4 router.

PE4#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter interface mode.
PE4(config-if)#ip address 10.0.1.44/32 secondary	Configure the IP address of the interface.
PE4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1

	instance.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#router ldp	Enter router ldp mode.
PE4(config-router)#exit	Exit router mode.
PE4(config)#interface eth4	Enter interface mode.
PE4(config-if)#ip address 10.44.2.1/30	Configure the IP address of the interface.
PE4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE4(config-if)#label-switching	Enable label switching.
PE4(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface
PE4(config-if)#exit	Exit interface mode.
PE4(config)#interface eth1	Enter interface mode.
PE4(config-if)#ip address 10.33.44.2/30	Configure the IP address of the interface.
PE4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE4(config-if)#label-switching	Enable label switching.
PE4(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface
PE4(config-if)#exit	Exit interface mode.
PE4(config)#router isis isis1	Set the routing process ID .
PE4(config-router)#metric-style wide	Configure metric style as wide.
PE4(config-router)#is-type level-1-2	Configure is-type.
PE4(config-router)#net 49.0000.0100.0000.1044.00	Configure Network Entity Title (NET).
PE4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE4(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE4(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process
PE4(config-router)#exit	Exit router mode.
PE4(config)#commit	Commit the candidate configuration to the running configuration.

**Notes:**

- Multiple nodes can act as SRMS nodes with their individual preferences
- The highest preference SRMS node SRMS entries will be advertised over lowest preference SRMS node.
- Non SR/LDP node i.e. Pure SR node also can act as SRMS node.

Validations

Validation 1

Verification on ISIS neighbor adjacency between routers.

```

PE1#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 3
Total number of adjacencies: 6
Tag isis1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
PE2            eth1      5254.00fb.2770    Up     8          L1  IS-IS
               eth1      5254.00fb.2770    Up     8          L2  IS-IS
P1             eth2      5254.008b.368d    Up     6          L1  IS-IS
               eth2      5254.008b.368d    Up     6          L2  IS-IS
P2             eth3      5254.0098.900b    Up     27         L1  IS-IS
               eth3      5254.0098.900b    Up     27         L2  IS-IS

PE2#show clns neighbors

Total number of L1 adjacencies: 3
Total number of L2 adjacencies: 3
Total number of adjacencies: 6
Tag isis1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
PE1            eth1      5254.000d.0625    Up     21         L1  IS-IS
               eth1      5254.000d.0625    Up     21         L2  IS-IS
P2             eth2      5254.008b.d24c    Up     21         L1  IS-IS
               eth2      5254.008b.d24c    Up     21         L2  IS-IS
P1             eth3      5254.0035.771c    Up     21         L1  IS-IS
               eth3      5254.0035.771c    Up     21         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 isis1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
P2            eth1      5254.00de.ca03    Up     7          L1  IS-IS
               eth1      5254.00de.ca03    Up     7          L2  IS-IS
PE1           eth2      5254.0060.8a75    Up     18         L1  IS-IS
               eth2      5254.0060.8a75    Up     18         L2  IS-IS
PE2           eth3      5254.00f2.5abf    Up     5          L1  IS-IS
               eth3      5254.00f2.5abf    Up     5          L2  IS-IS
PE3           eth4      5254.0085.7e32    Up     7          L1  IS-IS
               eth4      5254.0085.7e32    Up     7          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 isis1: VRF : default
System Id      Interface  SNPA          State Holdtime  Type Protocol
P1             eth1       5254.00a6.9153 Up    20        L1   IS-IS
               eth1       5254.00a6.9153 Up    20        L2   IS-IS
PE2            eth2       5254.00fb.3787 Up    7         L1   IS-IS
               eth2       5254.00fb.3787 Up    7         L2   IS-IS
PE1            eth3       5254.00ac.d346 Up    8         L1   IS-IS
               eth3       5254.00ac.d346 Up    8         L2   IS-IS
PE4            eth4       5254.00c8.98db Up    8         L1   IS-IS
               eth4       5254.00c8.98db Up    8         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 isis1: VRF : default
System Id      Interface  SNPA          State Holdtime  Type Protocol
PE4            eth1       5254.0007.09e5 Up    21        L1   IS-IS
               eth1       5254.0007.09e5 Up    21        L2   IS-IS
P1             eth4       5254.000d.673d Up    21        L1   IS-IS
               eth4       5254.000d.673d Up    21        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 isis1: VRF : default
System Id      Interface  SNPA          State Holdtime  Type Protocol
PE3            eth1       5254.00d0.4baf Up    6         L1   IS-IS
               eth1       5254.00d0.4baf Up    6         L2   IS-IS
P2            eth4       5254.0011.6e77 Up    28        L1   IS-IS
               eth4       5254.0011.6e77 Up    28        L2   IS-IS

```

Validation 2

Validation of routers configured with segment routing.

```

P1#show isis segment-routing capability

Tag isis1 Segment-Routing:
-----
Advertisement Router Capability :10.0.1.11
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :10.0.1.1
Algorithm0                     :0
SRMS Preference                :200
Total SID'S Supported          :6501
SID Range List Count           :1
SID's Range                    :17000 - 23500
-----
Advertisement Router Capability :10.0.1.22
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999

```

```

-----
Advertisement Router Capability :10.0.1.2
Algorithm0                     :0
SRMS Preference                :100
Total SID'S Supported          :6001
SID Range List Count           :1
SID's Range                    :16500 - 22500
-----

```

Validation 3

Verify that segment routing information is present ISIS database.

```

P1#show isis database verbose
Tag isis1: VRF : default
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
P1.00-00       * 0x0000025B  0x888A        856           0/0/0
  Area Address: 49.0000
  NLPID:       0xCC
  Hostname:    P1
  IP Address:  10.0.1.1
  Router ID:   10.0.1.1
  Router Cap:  10.0.1.1
    SRGB Range: 6501   SRGB Base SID: 17000   I:1 V:0
    SR-Algorithm:
      Algorithm: 0
    SRMS-Preference: 200
  Metric:      10      IS-Extended PE3.03
  IPv4 Interface Address: 10.33.1.2
  Neighbor IP Address: 10.33.1.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1033 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
  Metric:      10      IS-Extended P1.03
  IPv4 Interface Address: 10.11.1.2
  Neighbor IP Address: 10.11.1.2
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
  Metric:      10      IS-Extended P2.02
  IPv4 Interface Address: 10.1.2.1
  Neighbor IP Address: 10.1.2.2
  Maximum Link Bandwidth: 100m

```

```

Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE2.04
IPv4 Interface Address: 10.22.1.2
Neighbor IP Address: 10.22.1.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1022 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.1/32
Prefix-SID: index 200 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.11.1.0/30
Metric: 10 IP-Extended 10.33.1.0/30
Metric: 10 IP-Extended 10.22.1.0/30
SID Binding: 10.0.1.33/32 F:0 M:0 S:0 D:0 A:0 Range:1
SID: Start:1111 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
SID Binding: 10.0.1.44/32 F:0 M:0 S:0 D:0 A:0 Range:1
SID: Start:1555 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
P1.03-00 * 0x00000249 0x41FA 631 0/0/0
Metric: 0 IS-Extended P1.00
Metric: 0 IS-Extended PE1.00
P2.00-00 0x0000002C 0xBA48 892 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P2
IP Address: 10.0.1.2
Router ID: 10.0.1.2
Router Cap: 10.0.1.2
SRGB Range: 6001 SRGB Base SID: 16500 I:1 V:0
SR-Algorithm:
  Algorithm: 0
SRMS-Preference: 100
Metric: 10 IS-Extended P2.02
IPv4 Interface Address: 10.1.2.2
Neighbor IP Address: 10.1.2.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0

```

```

Metric: 10          IS-Extended PE2.03
IPv4 Interface Address: 10.22.2.2
Neighbor IP Address: 10.22.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1022 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.2
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE4.03
IPv4 Interface Address: 10.44.2.2
Neighbor IP Address: 10.44.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1044 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 10.0.1.2/32
Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 10.1.2.0/30
Metric: 10          IP-Extended 10.22.2.0/30
Metric: 10          IP-Extended 10.11.2.0/30
Metric: 10          IP-Extended 10.44.2.0/30
SID Binding: 10.0.1.33/32 F:0 M:0 S:0 D:0 A:0 Range:1
  SID: Start:2111 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
SID Binding: 10.0.1.44/32 F:0 M:0 S:0 D:0 A:0 Range:1
  SID: Start:2511 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
P2.02-00          0x00000018 0x700E 717 0/0/0
Metric: 0          IS-Extended P2.00
Metric: 0          IS-Extended P1.00
PE1.00-00          0x00000026 0xE434 710 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE1
IP Address: 10.0.1.11
Router ID: 10.0.1.11
Router Cap: 10.0.1.11

```

```

SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
SR-Algorithm:
  Algorithm: 0
Metric: 10         IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.1
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 26241 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IS-Extended P1.03
IPv4 Interface Address: 10.11.1.1
Neighbor IP Address: 10.11.1.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 26240 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IS-Extended PE2.02
IPv4 Interface Address: 10.11.22.1
Neighbor IP Address: 10.11.22.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1022 LAN Adjacency SID: 26242 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10         IP-Extended 10.11.1.0/30
Metric: 10         IP-Extended 10.11.2.0/30
Metric: 10         IP-Extended 10.11.22.0/30
PE1.04-00          0x00000018 0x85D7      663          0/0/0
Metric: 0          IS-Extended PE1.00
Metric: 0          IS-Extended P2.00
PE2.00-00          0x00000008 0xD4F9      623          0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE2
IP Address: 10.0.1.22
Router ID: 10.0.1.22
Router Cap: 10.0.1.22
SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
SR-Algorithm:

```

```

Algorithm: 0
Metric: 10          IS-Extended PE2.02
IPv4 Interface Address: 10.11.22.2
Neighbor IP Address: 10.11.22.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 25600 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE2.03
IPv4 Interface Address: 10.22.2.1
Neighbor IP Address: 10.22.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 25601 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE2.04
IPv4 Interface Address: 10.22.1.1
Neighbor IP Address: 10.22.1.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 25602 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 10.0.1.22/32
Prefix-SID: index 700 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10          IP-Extended 10.11.22.0/30
Metric: 10          IP-Extended 10.22.2.0/30
Metric: 10          IP-Extended 10.22.1.0/30
PE2.02-00           0x00000005 0xF749      653          0/0/0
Metric: 0           IS-Extended PE2.00
Metric: 0           IS-Extended PE1.00
PE2.03-00           0x00000005 0xC38B      653          0/0/0
Metric: 0           IS-Extended PE2.00
Metric: 0           IS-Extended P2.00
PE2.04-00           0x00000005 0xA8A6      653          0/0/0
Metric: 0           IS-Extended PE2.00
Metric: 0           IS-Extended P1.00
PE3.00-00           0x0000001F 0x9BB8      441          0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE3
IP Address: 10.0.1.33

```

```

Router ID: 10.0.1.33
Metric: 10 IS-Extended PE3.02
IPv4 Interface Address: 10.33.44.1
Neighbor IP Address: 10.33.44.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
Metric: 10 IS-Extended PE3.03
IPv4 Interface Address: 10.33.1.1
Neighbor IP Address: 10.33.1.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
Metric: 10 IP-Extended 10.0.1.33/32
Metric: 10 IP-Extended 10.33.44.0/30
Metric: 10 IP-Extended 10.33.1.0/30
Metric: 10 IP-Extended 10.1.45.0/24
PE3.02-00 0x00000017 0xE4F4 717 0/0/0
Metric: 0 IS-Extended PE3.00
Metric: 0 IS-Extended PE4.00
PE3.03-00 0x00000018 0x9A80 717 0/0/0
Metric: 0 IS-Extended PE3.00
Metric: 0 IS-Extended P1.00
PE4.00-00 0x0000001E 0x2DE1 469 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE4
IP Address: 10.0.1.44
Router ID: 10.0.1.44
Metric: 10 IS-Extended PE3.02
IPv4 Interface Address: 10.33.44.2
Neighbor IP Address: 10.33.44.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
Metric: 10 IS-Extended PE4.03
IPv4 Interface Address: 10.44.2.1
Neighbor IP Address: 10.44.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:

```



```

    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    Metric: 10          IP-Extended 10.0.1.44/32
    Metric: 10          IP-Extended 10.33.44.0/30
    Metric: 10          IP-Extended 10.44.2.0/30
    Metric: 10          IP-Extended 10.1.36.0/24
    PE4.03-00          0x00000017  0xC137      717      0/0/0
    Metric: 0          IS-Extended PE4.00
    Metric: 0          IS-Extended P2.00

IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
P1.00-00      * 0x000002BF  0x1EB5      1111          0/0/0
  Area Address: 49.0000
  NLPID:       0xCC
  Hostname:    P1
  IP Address:  10.0.1.1
  Router ID:   10.0.1.1
  Router Cap:  10.0.1.1
    SRGB Range: 6501   SRGB Base SID: 17000   I:1 V:0
    SR-Algorithm:
      Algorithm: 0
    SRMS-Preference: 200
    Metric: 10          IS-Extended PE3.03
    IPv4 Interface Address: 10.33.1.2
    Neighbor IP Address: 10.33.1.1
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100m
      Unreserved Bandwidth at priority 1: 100m
      Unreserved Bandwidth at priority 2: 100m
      Unreserved Bandwidth at priority 3: 100m
      Unreserved Bandwidth at priority 4: 100m
      Unreserved Bandwidth at priority 5: 100m
      Unreserved Bandwidth at priority 6: 100m
      Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1033 LAN Adjacency SID: 24320   F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IS-Extended P1.03
    IPv4 Interface Address: 10.11.1.2
    Neighbor IP Address: 10.11.1.2
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 100m
      Unreserved Bandwidth at priority 1: 100m
      Unreserved Bandwidth at priority 2: 100m
      Unreserved Bandwidth at priority 3: 100m
      Unreserved Bandwidth at priority 4: 100m
      Unreserved Bandwidth at priority 5: 100m
      Unreserved Bandwidth at priority 6: 100m
      Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1011 LAN Adjacency SID: 24321   F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IS-Extended P2.02
    IPv4 Interface Address: 10.1.2.1
    Neighbor IP Address: 10.1.2.2
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:

```

```

    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1002 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE2.04
  IPv4 Interface Address: 10.22.1.2
  Neighbor IP Address: 10.22.1.1
  Maximum Link Bandwidth: 100m
  Reservable Bandwidth: 100m
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
  TE-Default Metric: 10
  System-ID: 0100.0000.1022 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.1/32
  Prefix-SID: index 200 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.11.1.0/30
Metric: 10 IP-Extended 10.33.1.0/30
Metric: 20 IP-Extended 10.0.1.2/32
  Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.33/32
Metric: 30 IP-Extended 10.1.36.0/24
Metric: 20 IP-Extended 10.1.45.0/24
Metric: 20 IP-Extended 10.11.2.0/30
Metric: 20 IP-Extended 10.33.44.0/30
Metric: 20 IP-Extended 10.44.2.0/30
Metric: 20 IP-Extended 10.0.1.11/32
  Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 30 IP-Extended 10.0.1.44/32
Metric: 20 IP-Extended 10.11.22.0/30
Metric: 20 IP-Extended 10.22.2.0/30
Metric: 10 IP-Extended 10.22.1.0/30
Metric: 20 IP-Extended 10.0.1.22/32
  Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
SID Binding: 10.0.1.33/32 F:0 M:0 S:0 D:0 A:0 Range:1
  SID: Start:1111 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
SID Binding: 10.0.1.44/32 F:0 M:0 S:0 D:0 A:0 Range:1
  SID: Start:1555 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
P1.03-00 * 0x00000285 0xC837 633 0/0/0
Metric: 0 IS-Extended P1.00
Metric: 0 IS-Extended PE1.00
P2.00-00 0x00000065 0x4F33 1110 0/0/0
  Area Address: 49.0000
  NLPID: 0xCC
  Hostname: P2
  IP Address: 10.0.1.2
  Router ID: 10.0.1.2
  Router Cap: 10.0.1.2
  SRGB Range: 6001 SRGB Base SID: 16500 I:1 V:0
  SR-Algorithm:
    Algorithm: 0
  SRMS-Preference: 100
Metric: 10 IS-Extended P2.02
  IPv4 Interface Address: 10.1.2.2
  Neighbor IP Address: 10.1.2.2

```

```
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE2.03
IPv4 Interface Address: 10.22.2.2
Neighbor IP Address: 10.22.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1022 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.2
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE4.03
IPv4 Interface Address: 10.44.2.2
Neighbor IP Address: 10.44.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1044 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.2/32
  Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 20 IP-Extended 10.0.1.11/32
  Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.11.2.0/30
Metric: 10 IP-Extended 10.44.2.0/30
```

```

Metric: 30      IP-Extended 10.0.1.33/32
Metric: 20      IP-Extended 10.0.1.44/32
Metric: 20      IP-Extended 10.1.36.0/24
Metric: 20      IP-Extended 10.11.1.0/30
Metric: 20      IP-Extended 10.33.44.0/30
Metric: 30      IP-Extended 10.1.45.0/24
Metric: 20      IP-Extended 10.11.22.0/30
Metric: 20      IP-Extended 10.33.1.0/30
Metric: 20      IP-Extended 10.0.1.1/32
  Prefix-SID: index 200 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 10.22.2.0/30
Metric: 20      IP-Extended 10.0.1.22/32
  Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20      IP-Extended 10.22.1.0/30
SID Binding: 10.0.1.33/32 F:0 M:0 S:0 D:0 A:0 Range:1
  SID: Start:2111 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
SID Binding: 10.0.1.44/32 F:0 M:0 S:0 D:0 A:0 Range:1
  SID: Start:2511 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
P2.02-00      0x00000017 0x720D 717 0/0/0
  Metric: 0      IS-Extended P2.00
  Metric: 0      IS-Extended P1.00
PE1.00-00      0x00000061 0xBF77 1110 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE1
IP Address: 10.0.1.11
Router ID: 10.0.1.11
Router Cap: 10.0.1.11
  SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10      IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.1
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 26241 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended P1.03
IPv4 Interface Address: 10.11.1.1
Neighbor IP Address: 10.11.1.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 26240 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended PE2.02
IPv4 Interface Address: 10.11.22.1
Neighbor IP Address: 10.11.22.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m

```

```

Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1022 LAN Adjacency SID: 26242 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.11.1.0/30
Metric: 10 IP-Extended 10.11.2.0/30
Metric: 20 IP-Extended 10.0.1.2/32
Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.1.2.0/30
Metric: 20 IP-Extended 10.33.1.0/30
Metric: 30 IP-Extended 10.0.1.33/32
Metric: 30 IP-Extended 10.0.1.44/32
Metric: 30 IP-Extended 10.1.36.0/24
Metric: 30 IP-Extended 10.1.45.0/24
Metric: 20 IP-Extended 10.22.2.0/30
Metric: 30 IP-Extended 10.33.44.0/30
Metric: 20 IP-Extended 10.44.2.0/30
Metric: 20 IP-Extended 10.0.1.1/32
Prefix-SID: index 200 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.11.22.0/30
Metric: 20 IP-Extended 10.0.1.22/32
Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20 IP-Extended 10.22.1.0/30
PE1.04-00 0x00000016 0x89D5 717 0/0/0
Metric: 0 IS-Extended PE1.00
Metric: 0 IS-Extended P2.00
PE2.00-00 0x00000019 0xFF98 628 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE2
IP Address: 10.0.1.22
Router ID: 10.0.1.22
Router Cap: 10.0.1.22
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
Algorithm: 0
Metric: 10 IS-Extended PE2.02
IPv4 Interface Address: 10.11.22.2
Neighbor IP Address: 10.11.22.2
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 25600 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE2.03
IPv4 Interface Address: 10.22.2.1
Neighbor IP Address: 10.22.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m

```

```

    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1002 LAN Adjacency SID: 25601 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IS-Extended PE2.04
    IPv4 Interface Address: 10.22.1.1
    Neighbor IP Address: 10.22.1.1
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
        Unreserved Bandwidth at priority 0: 100m
        Unreserved Bandwidth at priority 1: 100m
        Unreserved Bandwidth at priority 2: 100m
        Unreserved Bandwidth at priority 3: 100m
        Unreserved Bandwidth at priority 4: 100m
        Unreserved Bandwidth at priority 5: 100m
        Unreserved Bandwidth at priority 6: 100m
        Unreserved Bandwidth at priority 7: 100m
    TE-Default Metric: 10
    System-ID: 0100.0000.1001 LAN Adjacency SID: 25602 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 10.0.1.22/32
    Prefix-SID: index 700 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 10 IP-Extended 10.11.22.0/30
    Metric: 10 IP-Extended 10.22.2.0/30
    Metric: 10 IP-Extended 10.22.1.0/30
    Metric: 20 IP-Extended 10.0.1.1/32
    Prefix-SID: index 200 R:1 N:0 P:0 E:0 V:0 L:0
    Metric: 20 IP-Extended 10.0.1.2/32
    Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
    Metric: 20 IP-Extended 10.0.1.11/32
    Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
    Metric: 30 IP-Extended 10.0.1.33/32
    Metric: 30 IP-Extended 10.0.1.44/32
    Metric: 20 IP-Extended 10.1.2.0/30
    Metric: 30 IP-Extended 10.1.36.0/24
    Metric: 30 IP-Extended 10.1.45.0/24
    Metric: 20 IP-Extended 10.11.1.0/30
    Metric: 20 IP-Extended 10.11.2.0/30
    Metric: 20 IP-Extended 10.33.1.0/30
    Metric: 30 IP-Extended 10.33.44.0/30
    Metric: 20 IP-Extended 10.44.2.0/30
    PE2.02-00 0x00000005 0xF749 653 0/0/0
    Metric: 0 IS-Extended PE2.00
    Metric: 0 IS-Extended PE1.00
    PE2.03-00 0x00000005 0xC38B 653 0/0/0
    Metric: 0 IS-Extended PE2.00
    Metric: 0 IS-Extended P2.00
    PE2.04-00 0x00000005 0xA8A6 653 0/0/0
    Metric: 0 IS-Extended PE2.00
    Metric: 0 IS-Extended P1.00
    PE3.00-00 0x00000059 0xA69A 1110 0/0/0
    Area Address: 49.0000
    NLPID: 0xCC
    Hostname: PE3
    IP Address: 10.0.1.33
    Router ID: 10.0.1.33
    Metric: 10 IS-Extended PE3.02
    IPv4 Interface Address: 10.33.44.1
    Neighbor IP Address: 10.33.44.1
    Maximum Link Bandwidth: 100m
    Reservable Bandwidth: 100m
    Unreserved Bandwidth:
        Unreserved Bandwidth at priority 0: 100m

```

```

    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
Metric: 10      IS-Extended PE3.03
IPv4 Interface Address: 10.33.1.1
Neighbor IP Address: 10.33.1.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
Metric: 10      IP-Extended 10.0.1.33/32
Metric: 10      IP-Extended 10.33.44.0/30
Metric: 10      IP-Extended 10.33.1.0/30
Metric: 10      IP-Extended 10.1.45.0/24
Metric: 30      IP-Extended 10.0.1.2/32
Metric: 30      IP-Extended 10.0.1.11/32
Metric: 20      IP-Extended 10.0.1.44/32
Metric: 20      IP-Extended 10.1.2.0/30
Metric: 20      IP-Extended 10.1.36.0/24
Metric: 20      IP-Extended 10.11.1.0/30
Metric: 30      IP-Extended 10.11.2.0/30
Metric: 30      IP-Extended 10.11.22.0/30
Metric: 30      IP-Extended 10.22.2.0/30
Metric: 20      IP-Extended 10.44.2.0/30
Metric: 20      IP-Extended 10.0.1.1/32
Metric: 30      IP-Extended 10.0.1.22/32
Metric: 20      IP-Extended 10.22.1.0/30
PE3.02-00      0x00000016  0xE6F3      717      0/0/0
Metric: 0      IS-Extended PE3.00
Metric: 0      IS-Extended PE4.00
PE3.03-00      0x00000017  0x9C7F      717      0/0/0
Metric: 0      IS-Extended PE3.00
Metric: 0      IS-Extended P1.00
PE4.00-00      0x0000005A  0x2BDC      1110     0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE4
IP Address: 10.0.1.44
Router ID: 10.0.1.44
Metric: 10      IS-Extended PE3.02
IPv4 Interface Address: 10.33.44.2
Neighbor IP Address: 10.33.44.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 100m
    Unreserved Bandwidth at priority 1: 100m
    Unreserved Bandwidth at priority 2: 100m
    Unreserved Bandwidth at priority 3: 100m
    Unreserved Bandwidth at priority 4: 100m
    Unreserved Bandwidth at priority 5: 100m
    Unreserved Bandwidth at priority 6: 100m
    Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
Metric: 10      IS-Extended PE4.03

```

```

IPv4 Interface Address: 10.44.2.1
Neighbor IP Address: 10.44.2.1
Maximum Link Bandwidth: 100m
Reservable Bandwidth: 100m
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100m
  Unreserved Bandwidth at priority 1: 100m
  Unreserved Bandwidth at priority 2: 100m
  Unreserved Bandwidth at priority 3: 100m
  Unreserved Bandwidth at priority 4: 100m
  Unreserved Bandwidth at priority 5: 100m
  Unreserved Bandwidth at priority 6: 100m
  Unreserved Bandwidth at priority 7: 100m
TE-Default Metric: 10
Metric: 10      IP-Extended 10.0.1.44/32
Metric: 10      IP-Extended 10.33.44.0/30
Metric: 10      IP-Extended 10.44.2.0/30
Metric: 10      IP-Extended 10.1.36.0/24
Metric: 20      IP-Extended 10.0.1.33/32
Metric: 20      IP-Extended 10.1.45.0/24
Metric: 20      IP-Extended 10.33.1.0/30
Metric: 20      IP-Extended 10.0.1.2/32
Metric: 30      IP-Extended 10.0.1.11/32
Metric: 20      IP-Extended 10.1.2.0/30
Metric: 30      IP-Extended 10.11.1.0/30
Metric: 20      IP-Extended 10.11.2.0/30
Metric: 30      IP-Extended 10.11.22.0/30
Metric: 20      IP-Extended 10.22.2.0/30
Metric: 30      IP-Extended 10.0.1.1/32
Metric: 30      IP-Extended 10.0.1.22/32
Metric: 30      IP-Extended 10.22.1.0/30
PE4.03-00      0x00000016  0xC336      717      0/0/0
Metric: 0      IS-Extended PE4.00
Metric: 0      IS-Extended P2.00

```

Validation 4

Show the details of mapping server entries advertised by SRMS.

```

P1#show segment-routing mapping-server prefix-sid-map ipv4 detail
Prefix
10.0.1.33/32
  SID Index:      1111
  Range:          1
  Last Prefix:    10.0.1.33/32
  Last SID Index: 1111
  Binding Flags:
  SRMS pref:      200
Prefix
10.0.1.44/32
  SID Index:      1555
  Range:          1
  Last Prefix:    10.0.1.44/32
  Last SID Index: 1555
  Binding Flags:
  SRMS pref:      200

Number of mapping entries: 2

P1#show isis segment-routing mapping-table ipv4 active
Tag isis1 Segment-Routing:
Conflict Resolution Policy: Quarantine

Prefix          SID Index      Range      Flags

```



```

10.0.1.1/32      200      1
10.0.1.2/32      300      1
10.0.1.11/32     100      1
10.0.1.22/32     700      1

Number of mapping entries in Active IPv4 Table: 4

P1#show isis segment-routing mapping-table ipv4 inactive
Tag isis1 Segment-Routing:
Conflict Resolution Policy: Quarantine

Prefix          SID Index      Range      Flags

Number of mapping entries in Inactive IPv4 Table: 0

```

Validation 5

Verify that segment routing is enabled and that prefix SIDs are announced to other routers.

Verify that prefix SIDs are installed as labels in the MPLS forwarding table. Verify the same in FTN and ILM tables.

```

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>    10.0.1.2/32    2        3        -          -    LSP_
DEFAULT 3        eth1      No        10.1.2.2
i      10.0.1.2/32    1        4        0          Yes  LSP_
DEFAULT 16800      eth1      No        10.1.2.2
i>    10.0.1.11/32   3        2        0          Yes  LSP_
DEFAULT 3        eth2      No        10.11.1.1
i>    10.0.1.22/32   5        6        0          Yes  LSP_
DEFAULT 3        eth3      No        10.22.1.1
L>    10.0.1.33/32   11       1        -          -    LSP_
DEFAULT 3        eth4      No        10.33.1.1
L>    10.0.1.44/32   6        5        -          -    LSP_
DEFAULT 25602      eth1      No        10.1.2.2
        -          -          -          -    LSP_
DEFAULT 24967      eth4      No        10.33.1.1
i      10.0.1.44/32   4        7        0          Yes  LSP_
DEFAULT 18055      eth1      No        10.1.2.2
L>    10.1.36.0/24   7        8        -          -    LSP_
DEFAULT 25603      eth1      No        10.1.2.2
        -          -          -          -    LSP_
DEFAULT 24968      eth4      No        10.33.1.1
L>    10.1.45.0/24   12       1        -          -    LSP_
DEFAULT 3        eth4      No        10.33.1.1
L>    10.11.2.0/30   8        3        -          -    LSP_
DEFAULT 3        eth1      No        10.1.2.2
L>    10.22.2.0/30   9        3        -          -    LSP_
DEFAULT 3        eth1      No        10.1.2.2
L>    10.33.44.0/30  13       1        -          -    LSP_
DEFAULT 3        eth4      No        10.33.1.1
L>    10.44.2.0/30   10       3        -          -    LSP_
DEFAULT 3        eth1      No        10.1.2.2

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>	10.11.22.0/30	30	25604	Nolabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT					
i>	10.33.1.1/32	18	24320	3	N/A	eth4	10.33
.1.1		LSP_DEFAULT					
i>	10.0.1.2/32	21	17300	16800	N/A	eth1	10.1.
2.2		LSP_DEFAULT					
i>	10.0.1.1/32	17	17200	Nolabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT					
i>	10.0.1.11/32	23	17100	3	N/A	eth2	10.11
.1.1		LSP_DEFAULT					
s							
i>	10.0.1.33/32	26	18111	3	N/A	eth4	10.33.1.
1		LSP_DEFAULT					
i>	10.0.1.22/32	39	17700	3	N/A	eth3	10.22
.1.1		LSP_DEFAULT					
i>	10.0.1.44/32	24	18555	18055	N/A	eth1	10.1.
2.2		LSP_DEFAULT					
s							
L>	10.0.1.11/32	22	25600	3	N/A	eth2	10.11.1.
1		LSP_DEFAULT					
i>	10.1.2.2/32	20	24322	3	N/A	eth1	10.1.
2.2		LSP_DEFAULT					
i>	10.11.1.1/32	19	24321	3	N/A	eth2	10.11
.1.1		LSP_DEFAULT					
i>	10.22.1.1/32	25	24323	3	N/A	eth3	10.22
.1.1		LSP_DEFAULT					
L>	10.0.1.33/32	28	25602	3	N/A	eth4	10.33
.1.1		LSP_DEFAULT					
s							
L>	10.0.1.22/32	27	25601	3	N/A	eth3	10.22.1.
1		LSP_DEFAULT					
L>	10.1.45.0/24	29	25603	3	N/A	eth4	10.33
.1.1		LSP_DEFAULT					
s							
L>	10.0.1.22/32	34	25608	3	N/A	eth3	10.22.1.
1		LSP_DEFAULT					
L>	10.0.1.2/32	32	25606	3	N/A	eth1	10.1.
2.2		LSP_DEFAULT					
L>	10.33.44.0/30	31	25605	3	N/A	eth4	10.33
.1.1		LSP_DEFAULT					
s							
L>	10.0.1.11/32	33	25607	3	N/A	eth2	10.11.1.
1		LSP_DEFAULT					
L>	10.11.22.0/30	36	25610	Nolabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT					
L>	10.11.2.0/30	35	25609	3	N/A	eth1	10.1.
2.2		LSP_DEFAULT					
L>	10.22.2.0/30	37	25611	3	N/A	eth1	10.1.
2.2		LSP_DEFAULT					
L>	10.44.2.0/30	38	25612	3	N/A	eth1	10.1.
2.2		LSP_DEFAULT					

Pl#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.2/32, 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

Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0

Cross connect ix: 5, 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: eth1, out label: 3
Next hop addr: 10.1.2.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 1, row status: Active
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 4
Owner: ISIS-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 4, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16800
Next hop addr: 10.1.2.2 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 3, row status: Active
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A
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: eth2, out label: 3
Next hop addr: 10.11.1.1 cross connect ix: 3, op code: Push

Stitched Ilm Info:

Ilm index 22, Incoming Interface index 0, In-Label 25600
Ilm index 33, Incoming Interface index 0, In-Label 25607

Primary FTN entry with FEC: 10.0.1.22/32, id: 5, row status: Active
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, Description: N/A
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 8, 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: eth3, out label: 3
Next hop addr: 10.22.1.1 cross connect ix: 8, op code: Push

Stitched Ilm Info:

Ilm index 27, Incoming Interface index 0, In-Label 25601
Ilm index 34, Incoming Interface index 0, In-Label 25608

Primary FTN entry with FEC: 10.0.1.33/32, id: 11, 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
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: eth4, out label: 3
Next hop addr: 10.33.1.1 cross connect ix: 1, op code: Push

Stitched Ilm Info:

Ilm index 26, Incoming Interface index 0, In-Label 18111

Primary FTN entry with FEC: 10.0.1.44/32, id: 6, 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
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
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: eth1, out label: 25602
Next hop addr: 10.1.2.2 cross connect ix: 7, op code: Push

Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 10
Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: eth4, out label: 24967

```
Nexthop addr: 10.33.1.1          cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 4, row status: Active
Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, Description: N/A
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 7
Owner: ISIS-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 7, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 18055
Nexthop addr: 10.1.2.2          cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.1.36.0/24, id: 7, 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
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 10, 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: eth1, out label: 25603
Nexthop addr: 10.1.2.2          cross connect ix: 10, op code: Push

Cross connect ix: 10, 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: eth4, out label: 24968
Nexthop addr: 10.33.1.1          cross connect ix: 10, op code: Push

Primary FTN entry with FEC: 10.1.45.0/24, id: 12, 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
Matched bytes:208, pkts:4, TX bytes:208, Pushed pkts:4
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: eth4, out label: 3
Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.11.2.0/30, id: 8, 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
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, 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: eth1, out label: 3
Nexthop addr: 10.1.2.2          cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.22.2.0/30, id: 9, 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
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, 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: eth1, out label: 3
Nexthop addr: 10.1.2.2          cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.33.44.0/30, id: 13, 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
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: eth4, out label: 3
Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Push
```

```
Primary FTN entry with FEC: 10.44.2.0/30, id: 10, 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
Matched bytes:0, pkts:0, TX bytes:0, Pushed pkts:0
Cross connect ix: 5, 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: eth1, out label: 3
Nexthop addr: 10.1.2.2          cross connect ix: 5, op code: Push
```

```
P1#show mpls in-segment-table
```

```
Owner: LDP, # of pops: 1, fec: 10.11.22.0/30, ILM-ID: 30
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 25604 out-segment ix: 0
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
Nexthop addr: 127.0.0.1          cross connect ix: 1, op code: Pop
```

```
Owner: ISIS-SR, # of pops: 1, fec: 10.33.1.1/32, ILM-ID: 18
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 24320 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: eth4, out label: 3
Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Swap
```

```
Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 21
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 6, in intf: - in label: 17300 out-segment ix: 4
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16800
Nexthop addr: 10.1.2.2          cross connect ix: 6, op code: Swap
```

```
Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.1/32, ILM-ID: 17
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 17200 out-segment ix: 0
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
Nexthop addr: 127.0.0.1          cross connect ix: 1, op code: Pop
```

```
Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 23
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 3, in intf: - in label: 17100 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: eth2, out label: 3
Nexthop addr: 10.11.1.1          cross connect ix: 3, op code: Swap
```

```
Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 26
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 18111 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: eth4, out label: 3
Nexthop addr: 10.33.1.1          cross connect ix: 1, op code: Swap
```

```
Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.22/32, ILM-ID: 39
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 8, in intf: - in label: 17700 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: eth3, out label: 3
Nexthop addr: 10.22.1.1          cross connect ix: 8, op code: Swap
```

Owner: ISIS-SR, # of pops: 1, fec: 10.0.1.44/32, ILM-ID: 24
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 9, in intf: - in label: 18555 out-segment ix: 7
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 18055
Nexthop addr: 10.1.2.2 cross connect ix: 9, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 22
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 3, in intf: - in label: 25600 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: eth2, out label: 3
Nexthop addr: 10.11.1.1 cross connect ix: 3, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.1.2.2/32, ILM-ID: 20
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 5, in intf: - in label: 24322 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: eth1, out label: 3
Nexthop addr: 10.1.2.2 cross connect ix: 5, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.11.1.1/32, ILM-ID: 19
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 3, in intf: - in label: 24321 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: eth2, out label: 3
Nexthop addr: 10.11.1.1 cross connect ix: 3, op code: Swap

Owner: ISIS-SR, # of pops: 1, fec: 10.22.1.1/32, ILM-ID: 25
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 8, in intf: - in label: 24323 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: eth3, out label: 3
Nexthop addr: 10.22.1.1 cross connect ix: 8, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 28
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 25602 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: eth4, out label: 3
Nexthop addr: 10.33.1.1 cross connect ix: 1, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.0.1.22/32, ILM-ID: 27
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 8, in intf: - in label: 25601 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: eth3, out label: 3
Nexthop addr: 10.22.1.1 cross connect ix: 8, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.1.45.0/24, ILM-ID: 29
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 25603 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: eth4, out label: 3
Nexthop addr: 10.33.1.1 cross connect ix: 1, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.0.1.22/32, ILM-ID: 34
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 8, in intf: - in label: 25608 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: eth3, out label: 3
Nexthop addr: 10.22.1.1          cross connect ix: 8, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 32
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 5, in intf: - in label: 25606 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: eth1, out label: 3
Nexthop addr: 10.1.2.2          cross connect ix: 5, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.33.44.0/30, ILM-ID: 31
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 25605 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: eth4, out label: 3
Nexthop addr: 10.33.1.1        cross connect ix: 1, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 33
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 3, in intf: - in label: 25607 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: eth2, out label: 3
Nexthop addr: 10.11.1.1        cross connect ix: 3, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.11.22.0/30, ILM-ID: 36
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 1, in intf: - in label: 25610 out-segment ix: 0
Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
Nexthop addr: 127.0.0.1        cross connect ix: 1, op code: Pop

Owner: LDP, # of pops: 1, fec: 10.11.2.0/30, ILM-ID: 35
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 5, in intf: - in label: 25609 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: eth1, out label: 3
Nexthop addr: 10.1.2.2        cross connect ix: 5, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.22.2.0/30, ILM-ID: 37
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 5, in intf: - in label: 25611 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: eth1, out label: 3
Nexthop addr: 10.1.2.2        cross connect ix: 5, op code: Swap

Owner: LDP, # of pops: 1, fec: 10.44.2.0/30, ILM-ID: 38
RX bytes:0, pkts:0, TX bytes:0, Swapped pkts:0, Popped pkts:0
Cross connect ix: 5, in intf: - in label: 25612 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: eth1, out label: 3
Nexthop addr: 10.1.2.2        cross connect ix: 5, op code: Swap

P1#show mpls out-segment-table
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: eth2, out label: 3
Nexthop addr: 10.11.1.1        cross connect ix: 3, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0
```

Out-segment with ix: 4, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16800
Nexthop addr: 10.1.2.2 cross connect ix: 6, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: eth1, out label: 3
Nexthop addr: 10.1.2.2 cross connect ix: 5, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: eth1, out label: 25602
Nexthop addr: 10.1.2.2 cross connect ix: 7, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 7, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 18055
Nexthop addr: 10.1.2.2 cross connect ix: 9, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: eth1, out label: 25603
Nexthop addr: 10.1.2.2 cross connect ix: 10, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 1, owner: N/A, Stale: NO, out intf: eth4, out label: 3
Nexthop addr: 10.33.1.1 cross connect ix: 1, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 6, owner: N/A, Stale: NO, out intf: eth3, out label: 3
Nexthop addr: 10.22.1.1 cross connect ix: 8, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 11, owner: LDP, Stale: NO, out intf: eth4, out label: 24968
Nexthop addr: 10.33.1.1 cross connect ix: 10, op code: Push

TX bytes:0, pkts:0, error pkts:0, discard pkts:0

Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: eth4, out label: 24967
Nexthop addr: 10.33.1.1 cross connect ix: 7, op code: Push

T
X bytes:0, pkts:0, error pkts:0, discard pkts:0

Configuring OSPF Intra-Area Segment Routing

This section shows how to configure segment routing between routers in the same area.

The segment routing capabilities of a router are advertised to other routers through the Router Information opaque LSA.

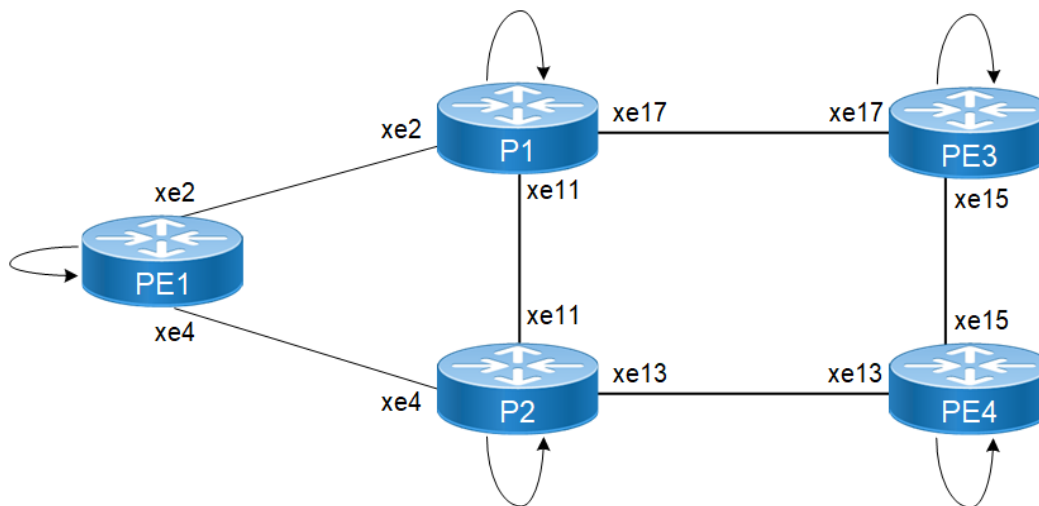
Prefix SIDs are advertised through the Extended Prefix opaque LSA which supports multiple Extended Prefix TLVs containing subTLVs to carry the prefix and corresponding SID information.

Topology

[Figure 17](#) shows the configuration required to enable OSPF segment routing at a global level and configure a prefix SID at the interface level.

You can configure a prefix SID on any router directly attached to that network prefix. In most cases configuring only one router is sufficient. If a prefix SID with the same prefix is configured on different routers, IP Infusion Inc. recommends that all SID values be the same.

Figure 17. OSPF Intra-Area Segment Routing Topology



Note: You must ensure that prefix SIDs are globally unique. Do not configure the same SID on different prefixes.

Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

```
PE1#configure terminal
```

Enter configure mode.

PE1(config)#int xe2	Enter interface mode.
PE1(config-if)#ip address 10.11.1.1/30	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
R2(config-if)#exit	Exit interface mode.
PE1(config)#int xe4	Enter interface mode.
PE1(config-if)#ip address 10.11.2.1/30	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#int lo	Enter interface mode.
PE1(config-if)#ip address 10.0.1.11/32 secondary	Configure the IP address of the interface.
PE1(config-if)#prefix-sid absolute 16000 no-php	Assign the prefix sid values
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router ospf 1	Enter OSPF router mode for process ID 1.
PE1(config-router)#router-id 10.0.1.11	Set the router-id
PE1(config-router)#network 10.0.1.11/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
PE1(config-router)#network 10.11.1.0/30 area 0.0.0.0	Advertise the xe2 interface in OSPF area 0.
PE1(config-router)#network 10.11.2.0/30 area 0.0.0.0	Advertise the xe4 interface in OSPF area 0.
PE1(config-router)#ospf segment-routing global block 16000 23999	Enable SRGB range under OSPF process.
PE1(config-router)#segment-routing mpls	Enable segment routing for the OSPF process.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration.

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#int lo	Enter interface mode.
P1(config-if)#ip address 10.0.1.1/32 secondary	Configure the IP address of the interface.
P1(config-if)#prefix-sid index 1000 no-php	Set the SID value.
P1(config-if)#exit	Exit interface mode.
P1(config)#int xe2	Enter interface mode.

P1(config-if)#ip address 10.11.1.2/30	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#int xe11	Enter interface mode.
P1(config-if)#ip address 10.1.1.1/30	Configure the IP address of the loopback interface.
P1(nfig-if)#label-switching	Enable label switching
P1(config-if)#exit	Exit interface mode.
P1(config)#int xe17	Enter interface mode.
P1(config-if)#ip address 10.33.1.2/30	Configure the IP address of the loopback interface.
P1(nfig-if)#label-switching	Enable label switching
P1(config-if)#exit	Exit interface mode.
P1(config)#router ospf 1	Enter OSPF router mode for process ID 1.
P1(config-router)#router-id 10.0.1.1	Set the router-id
P1(config-router)#network 10.0.1.1/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
P1(config-router)#network 10.1.1.0/30 area 0.0.0.0	Advertise the xe2 interface in OSPF area 0.
P1(config-router)#network 10.11.1.0/30 area 0.0.0.0	Advertise the xe11 interface in OSPF area 0.
P1(config-router)#network 10.33.1.0/30 area 0.0.0.0	Advertise the xe17 interface in OSPF area 0.
P1(config)#ospf segment-routing global block 16000 23999	Enable SRGB range under OSPF process.
P1(config-router)#segment-routing mpls	Enable segment routing for the OSPF process.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit the candidate configuration to the running configuration.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#int lo	Enter interface mode.
P2(config-if)#ip address 10.0.1.2/32 secondary	Configure the IP address of the interface.
P2(config-if)#prefix-sid index 2000 no-php	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#int xe4	Enter interface mode.
P2(config-if)#ip address 10.11.2.2/30	Configure the IP address of the interface.

P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#int xe11	Enter interface mode.
P2(config-if)#ip address 10.1.1.2/30	Configure the IP address of the loopback interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#int xe13	Enter interface mode.
P2(config-if)#ip address 10.44.2.2/30	Configure the IP address of the loopback interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ospf 1	Enter OSPF router mode for process ID 1.
P2(config-router)#router-id 10.0.1.2	Advertise the router-id.
P2(config-router)#network 10.0.1.2/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
P2(config-router)#network 10.1.1.0/30 area 0.0.0.0	Advertise the xe11 interface in OSPF area 0.
P2(config-router)#network 10.11.2.0/30 area 0.0.0.0	Advertise the xe4 interface in OSPF area 0.
P2(config-router)#network 10.44.2.0/30 area 0.0.0.0	Advertise the xe13 interface in OSPF area 0.
P2(config)#ospf segment-routing global block 16000 23999	Enable SRGB range under OSPF process.
P2(config-router)#segment-routing mpls	Enable segment routing for the OSPF process.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit the candidate configuration to the running configuration.

PE3

The following are the step-by-step configurations on the PE3 router.

PE3#configure terminal	Enter configure mode.
PE3(config)#int lo	Enter interface mode.
PE3(config-if)#ip address 10.0.1.33/32 secondary	Configure the IP address of the interface.
PE3(config-if)#prefix-sid absolute 19000 no-php	Enable label switching.
PE3(config-if)#exit	Exit interface mode.
PE3(config)#int xe15	Enter interface mode.
PE3(config-if)#ip address 10.33.44.1/30	Configure the IP address of the loopback interface.

PE3(config-if)#label-switching	Enable Label switching
PE3(config-if)#exit	Exit interface mode.
PE3(config)#int xe17	Enter interface mode.
PE3(config-if)#ip address 10.33.1.1/30	Configure the IP address of the loopback interface.
PE3(config-if)#label-switching	Enable Label switching
PE3(config-if)#exit	Exit interface mode.
PE3(config)#router ospf 1	Enter OSPF router mode for process ID 1.
PE3(config-router)#router-id 10.0.1.33	Advertise the router-id..
PE3(config-router)#network 10.0.1.33/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
PE3(config-router)#network 10.33.1.0/30 area 0.0.0.0	Advertise the xe15 interface in OSPF area 0.
PE3(config-router)#network 10.33.44.0/30 area 0.0.0.0	Advertise the xe17 interface in OSPF area 0.
PE3(config-router)#ospf segment-routing global block 16000 23999	Enable SRGB range under OSPF process.
PE3(config-router)#segment-routing mpls	Enable segment routing for OSPF process.
PE3(config-if)#exit	Exit interface mode.
PE3(config)#commit	Commit the candidate configuration to the running configuration.

PE4

The following are the step-by-step configurations on the PE4 router.

PE4#configure terminal	Enter configure mode
PE4(config)#int lo	Enter interface mode.
PE4(config-if)#ip address 10.0.1.44/32 secondary	Configure the IP address of the interface.
PE4(config-if)#prefix-sid absolute 20000 no-php	Enable label switching.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#int xe13	Enter interface mode.
PE4(config-if)#ip address 10.44.2.1/30	Configure the IP address of the loopback interface.
PE4(config-if)#label-switching	Enable Label switching
PE4(config-if)#exit	Exit interface mode.
PE4(config)#int xe15	Enter interface mode.
PE4(config-if)#ip address 10.33.44.2/30	Configure the IP address of the loopback interface.
PE4(config-if)#label-switching	Enable Label switching
PE4(config-if)#exit	Exit interface mode.

PE4(config)#router ospf 1	Enter OSPF router mode for process ID 1.
PE4(config-router)#router-id 10.0.1.44	Advertise the router-id..
PE4(config-router)#network 10.0.1.44/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
PE4(config-router)#network 10.33.44.0/30 area 0.0.0.0	Advertise the xe13 interface in OSPF area 0.
PE4(config-router)#network 10.44.2.0/30 area 0.0.0.0	Advertise the xe15 interface in OSPF area 0.
PE4(config-router)#ospf segment-routing global block 16000 23999	Enable SRGB range under OSPF process.
PE4(config-router)#segment-routing mpls	Enable segment routing for OSPF process.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#commit	Commit the candidate configuration to the running configuration.

Validation

Validation 1

Verify OSPF neighbor adjacency between all 5 routers.

```
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
10.0.1.1	1	Full/Backup	00:00:32	10.11.1.2	xe2	0
10.0.1.2	1	Full/Backup	00:00:37	10.11.2.2	xe4	0

```
P1#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
10.0.1.2	1	Full/Backup	00:00:29	10.1.1.2	xe11	0
10.0.1.11	1	Full/DR	00:00:37	10.11.1.1	xe2	0
10.0.1.33	1	Full/Backup	00:00:35	10.33.1.1	xe17	0

```
P2#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
10.0.1.1	1	Full/DR	00:00:28	10.1.1.1	xe11	0
10.0.1.11	1	Full/DR	00:00:34	10.11.2.1	xe4	0
10.0.1.44	1	Full/Backup	00:00:34	10.44.2.1	xe13	0

```
PE3#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
10.0.1.1	1	Full/DR	00:00:31	10.33.1.2	xe17	0
10.0.1.44	1	Full/Backup	00:00:29	10.33.44.2	xe15	0

```
PE4#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
10.0.1.33	1	Full/DR	00:00:38	10.33.44.1	xe15	0
10.0.1.2	1	Full/DR	00:00:37	10.44.2.2	xe13	0

Validation 2

Verify that segment routing is enabled and that prefix SIDs are announced to other routers via OSPF opaque LSAs.

Verify that labels are in the MPLS forwarding table and that prefix SIDs are installed.

Verify the same in FTN and ILM tables.

```
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					
O>	10.0.1.1/32	1	0	Yes	LSP_		
DEFAULT	17000	xe2	No	10.11.1.2			
O>	10.0.1.2/32	2	0	Yes	LSP_		
DEFAULT	18000	xe4	No	10.11.2.2			
O>	10.0.1.33/32	3	0	Yes	LSP_		
DEFAULT	19000	xe2	No	10.11.1.2			
O>	10.0.1.44/32	4	0	Yes	LSP_		
DEFAULT	20000	xe4	No	10.11.2.2			

```
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	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	ELC	Nexthop					
O>	10.0.1.2/32	2	0	Yes	LSP_		
DEFAULT	18000	xe11	No	10.1.1.2			
O>	10.0.1.11/32	1	0	Yes	LSP_		
DEFAULT	16000	xe2	No	10.11.1.1			
O>	10.0.1.33/32	3	0	Yes	LSP_		
DEFAULT	19000	xe17	No	10.33.1.1			
O>	10.0.1.44/32	4	0	Yes	LSP_		
DEFAULT	20000	xe11	No	10.1.1.2			

```
P2#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					
O>	10.0.1.1/32	1	0	Yes	LSP_		
DEFAULT	17000	xe11	No	10.1.1.1			
O>	10.0.1.11/32	2	0	Yes	LSP_		
DEFAULT	16000	xe4	No	10.11.2.1			
O>	10.0.1.33/32	3	0	Yes	LSP_		
DEFAULT	19000	xe13	No	10.44.2.1			
O>	10.0.1.44/32	4	0	Yes	LSP_		
DEFAULT	20000	xe13	No	10.44.2.1			

```

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

Code   FEC           FTN-ID   Tunnel-id   Pri   LSP-Type   Out-Label   Out-
Intf   ELC           Nexthop
O>     10.0.1.1/32      1       0           Yes   LSP_
DEFAULT 17000         xe17     No          10.33.1.2
O>     10.0.1.2/32      2       0           Yes   LSP_
DEFAULT 18000         xe17     No          10.33.1.2
O>     10.0.1.11/32     3       0           Yes   LSP_
DEFAULT 16000         xe17     No          10.33.1.2
O>     10.0.1.44/32     4       0           Yes   LSP_
DEFAULT 20000         xe15     No          10.33.44.2

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
O>     10.0.1.1/32      1       0           Yes   LSP_
DEFAULT 17000         xe13     No          10.44.2.2
O>     10.0.1.2/32      2       0           Yes   LSP_
DEFAULT 18000         xe13     No          10.44.2.2
O>     10.0.1.11/32     3       0           Yes   LSP_
DEFAULT 16000         xe13     No          10.44.2.2
O>     10.0.1.33/32     4       0           Yes   LSP_
DEFAULT 19000         xe15     No          10.33.44.1

```

In the forwarding tables above, the configured prefix SIDs are in the Out-Label column which is expected and is global across the topology. The swap happens in between nodes with this prefix SID and there is no local labelling.

Verify the ILM and FTN tables.

```

PE1#show mpls ftn-table
Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 2
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 17000
Nexthop addr: 10.11.1.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe4, out label: 18000
Nexthop addr: 10.11.2.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7

```



```

Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 19000
Nexthop addr: 10.11.1.2          cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0,   Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: OSPF-SR, Stale: NO, out intf: xe4, out label: 20000
Nexthop addr: 10.11.2.2          cross connect ix: 7, 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 Intf/VRF	ILM-ID Nexthop	In-Label LSP-Type	Out-Label	In-Intf	Out-	
O>	10.0.1.2/32	5	18000	18000	N/A	xe4	10.11
.2.2		LSP_DEFAULT					
O>	10.0.1.1/32	3	17000	17000	N/A	xe2	10.11
.1.2		LSP_DEFAULT					
O>	10.0.1.11/32	1	16000	Nolabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT					
O>	10.11.1.2/32	2	24320	3	N/A	xe2	10.11
.1.2		LSP_DEFAULT					
O>	10.0.1.33/32	6	19000	19000	N/A	xe2	10.11
.1.2		LSP_DEFAULT					
O>	10.0.1.44/32	7	20000	20000	N/A	xe4	10.11
.2.2		LSP_DEFAULT					
O>	10.11.2.2/32	4	24321	3	N/A	xe4	10.11
.2.2		LSP_DEFAULT					

Here, the ILM Entry for In-Label 24320 is for the adjacency SID. The rest of the entries are for the prefix SID.

P1#show mpls ftn-table

```

Primary FTN entry with FEC: 10.0.1.2/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0,   Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 18000
Nexthop addr: 10.1.1.2          cross connect ix: 4, op code: Push

```

```

Primary FTN entry with FEC: 10.0.1.11/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0,   Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 16000
Nexthop addr: 10.11.1.1          cross connect ix: 1, op code: Push

```

```

Primary FTN entry with FEC: 10.0.1.33/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none

```

```

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe17, out label: 19000
Nexthop addr: 10.33.1.1 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 12
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 12, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 20000
Nexthop addr: 10.1.1.2 cross connect ix: 8, op code: Push

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
O> 10.0.1.2/32      5         18000      18000      N/A       xe11      10.1.
1.2      LSP_DEFAULT
O> 10.0.1.1/32      3         17000      Nolabel    N/A       N/A       127.0
.0.1     LSP_DEFAULT
O> 10.0.1.11/32     1         16000      16000      N/A       xe2       10.11
.1.1     LSP_DEFAULT
O> 10.11.1.1/32     2         24320      3          N/A       xe2       10.11
.1.1     LSP_DEFAULT
O> 10.0.1.33/32     6         19000      19000      N/A       xe17      10.33
.1.1     LSP_DEFAULT
O> 10.0.1.44/32     8         20000      20000      N/A       xe11      10.1.
1.2      LSP_DEFAULT
O> 10.1.1.2/32      4         24321      3          N/A       xe11      10.1.
1.2      LSP_DEFAULT
O> 10.33.1.1/32     7         24322      3          N/A       xe17      10.33
.1.1     LSP_DEFAULT

P2#show mpls ftn-table
Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 17000
Nexthop addr: 10.1.1.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: OSPF-SR, Stale: NO, out intf: xe4, out label: 16000
Nexthop addr: 10.11.2.1 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11

```

Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 11, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 19000
 Nexthop addr: 10.44.2.1 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 4, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 20000
 Nexthop addr: 10.44.2.1 cross connect ix: 5, op code: Push

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				
O>	10.0.1.2/32	5	18000	Nolabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT					
O>	10.0.1.1/32	1	17000	17000	N/A	xe11	10.1.
1.1		LSP_DEFAULT					
O>	10.0.1.11/32	2	16000	16000	N/A	xe4	10.11
.2.1		LSP_DEFAULT					
O>	10.1.1.1/32	3	24320	3	N/A	xe11	10.1.
1.1		LSP_DEFAULT					
O>	10.0.1.33/32	6	19000	19000	N/A	xe13	10.44
.2.1		LSP_DEFAULT					
O>	10.0.1.44/32	7	20000	20000	N/A	xe13	10.44
.2.1		LSP_DEFAULT					
O>	10.11.2.1/32	4	24321	3	N/A	xe4	10.11
.2.1		LSP_DEFAULT					
O>	10.44.2.1/32	8	24322	3	N/A	xe13	10.44
.2.1		LSP_DEFAULT					

PE3#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe17, out label: 17000
 Nexthop addr: 10.33.1.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 2, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe17, out label: 18000
 Nexthop addr: 10.33.1.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 3, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
 none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe17, out label: 16000

Nexthop addr: 10.33.1.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 4, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 8, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 20000
 Nexthop addr: 10.33.44.2 cross connect ix: 5, op code: Push

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

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-	
Intf/VRF	Nexthop		LSP-Type				
O>	10.0.1.33/32	1	19000	NoLabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT					
O>	10.0.1.1/32	2	17000	17000	N/A	xe17	10.33
.1.2		LSP_DEFAULT					
O>	10.0.1.11/32	4	16000	16000	N/A	xe17	10.33
.1.2		LSP_DEFAULT					
O>	10.0.1.2/32	3	18000	18000	N/A	xe17	10.33
.1.2		LSP_DEFAULT					
O>	10.33.1.2/32	5	24320	3	N/A	xe17	10.33
.1.2		LSP_DEFAULT					
O>	10.0.1.44/32	6	20000	20000	N/A	xe15	10.33
.44.2		LSP_DEFAULT					
O>	10.33.44.2/32	7	24321	3	N/A	xe15	10.33
.44.2		LSP_DEFAULT					

PE4#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 10
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 10, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 17000
 Nexthop addr: 10.44.2.2 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 2, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 18000
 Nexthop addr: 10.44.2.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 3, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 16000
 Nexthop addr: 10.44.2.2 cross connect ix: 2, op code: Push

```

Primary FTN entry with FEC: 10.0.1.33/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 7
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 19000
Nexthop addr: 10.33.44.1 cross connect ix: 4, op code: Push

```

```
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 Intf/VRF	Nextthop	ILM-ID	In-Label LSP-Type	Out-Label	In-Intf	Out-	
O>	10.0.1.33/32		5	19000	19000	N/A	xe15	10.33
.44.1		LSP_DEFAULT						
O>	10.0.1.1/32		2	17000	17000	N/A	xe13	10.44
.2.2		LSP_DEFAULT						
O>	10.0.1.11/32		4	16000	16000	N/A	xe13	10.44
.2.2		LSP_DEFAULT						
O>	10.0.1.2/32		3	18000	18000	N/A	xe13	10.44
.2.2		LSP_DEFAULT						
O>	10.33.44.1/32		6	24320	3	N/A	xe15	10.33
.44.1		LSP_DEFAULT						
O>	10.0.1.44/32		1	20000	NoLabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT						
O>	10.44.2.2/32		7	24321	3	N/A	xe13	10.44
.2.2		LSP_DEFAULT						

Validation 3

The command output below displays the details of routers configured with segment routing.

```
PE1#show ip ospf segment-routing capability
```

```
OSPF process 1:
```

```

-----
Advertisement Router Capability :10.0.1.1
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----

```

```

Advertisement Router Capability :10.0.1.2
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----

```

```

Advertisement Router Capability :10.0.1.11
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999

```

```

-----
Advertisement Router Capability :10.0.1.33
Algorithm                     :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----
Advertisement Router Capability :10.0.1.44
Algorithm                     :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----

```

The command below displays the database details where a prefix SID is advertised through opaque LSAs.

```

PE1#show ip ospf database opaque-area self-originate

      OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 569
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.11
LS Seq Number: 80000004
Checksum: 0x40bf
Length: 28

MPLS TE router ID : 10.0.1.11

Number of Links : 0

LS age: 663
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x6abc
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

```

```

LS age: 569
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.16 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 16
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x74ac
Length: 108

Link connected to Broadcast network
Link ID : 10.11.2.1
Interface Address : 10.11.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 758
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x705b
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 758
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x94d6
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 663
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA

```

```

Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x1588
Length: 52

```

```

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.1
SID: 24320

```

```

LS age: 569
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x5e39
Length: 52

```

```

Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.2
SID: 24321

```

```
PE1#show ip ospf database opaque-area
```

```
OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)
```

```
Area-Local Opaque-LSA (Area 0.0.0.0)
```

```

LS age: 560
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000004
Checksum: 0x18fb
Length: 28

```

```
MPLS TE router ID : 10.0.1.1
```

```
Number of Links : 0
```

```

LS age: 557
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000003

```



```
Checksum: 0x1ef4
Length: 28

MPLS TE router ID : 10.0.1.2

Number of Links : 0

LS age: 556
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.11
LS Seq Number: 80000004
Checksum: 0x40bf
Length: 28

MPLS TE router ID : 10.0.1.11

Number of Links : 0

LS age: 385
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000003
Checksum: 0x9a3a
Length: 28

MPLS TE router ID : 10.0.1.33

Number of Links : 0

LS age: 377
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
Checksum: 0xc6f7
Length: 28

MPLS TE router ID : 10.0.1.44

Number of Links : 0

LS age: 652
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xc46b
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
```

```
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 651
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x6abc
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 557
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.16 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 16
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xc860
Length: 108

Link connected to Broadcast network
Link ID : 10.11.2.1
Interface Address : 10.11.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 556
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.16 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 16
```

Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x74ac
Length: 108

Link connected to Broadcast network

Link ID : 10.11.2.1
Interface Address : 10.11.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 560
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x1023
Length: 108

Link connected to Broadcast network

Link ID : 10.1.1.1
Interface Address : 10.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 561
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x2809
Length: 108

Link connected to Broadcast network

Link ID : 10.1.1.1
Interface Address : 10.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s

```

Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 377
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 376
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.34 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 34
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6073
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 385
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x87ee
Length: 108

Link connected to Broadcast network

```

```

Link ID : 10.33.44.1
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 385
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6307
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.1
Interface Address : 10.33.44.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 490
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.40 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 40
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x07c0
Length: 108

Link connected to Broadcast network
Link ID : 10.33.1.2
Interface Address : 10.33.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 489
Options: 0x22 (-|-|DC|-|-|-|E|-)

```

```

LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.42 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 42
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xd113
Length: 108

Link connected to Broadcast network
Link ID : 10.33.1.2
Interface Address : 10.33.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 657
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xac29
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 570
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xa62e
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 746
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x705b
Length: 44

Range Size: 8000

```

```

Base-SID: 16000
Algorithm: 0

LS age: 502
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 409
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 622
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x7ddc
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

LS age: 552
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x77f4
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

LS age: 746
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x94d6
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 502
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 409
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV

```



```
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

LS age: 652
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x0fb0
Length: 48

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320

LS age: 651
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x1588
Length: 52

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.1
SID: 24320

LS age: 557
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x3089
Length: 48

Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
```

SID: 24321

LS age: 556
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x5e39
Length: 52

Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.2
SID: 24321

LS age: 560
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x1d93
Length: 52

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.2
SID: 24321

LS age: 561
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x9534
Length: 48

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320

LS age: 377
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA

```
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x7ec6
Length: 48
```

```
Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24321
```

```
LS age: 376
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.31 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10015
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x0c1c
Length: 52
```

```
Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.44
SID: 24322
```

```
LS age: 385
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xc10b
Length: 52
```

```
Link Type: 2
Link ID: 10.33.44.1
Link Data: 10.33.44.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.44
SID: 24321
```

```
LS age: 385
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x0df8
```

Length: 48

Link Type: 2
 Link ID: 10.33.44.1
 Link Data: 10.33.44.2
 Flags: 0x60 (-|V|L|-|-|-|-)
 MT-ID: 0
 Weight: 0
 SID: 24320

LS age: 490
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 8.0.39.34 (Area-Local Opaque-Type/ID)
 Opaque Type: 8
 Opaque ID: 10018
 Advertising Router: 10.0.1.33
 LS Seq Number: 80000001
 Checksum: 0x283d
 Length: 48

Link Type: 2
 Link ID: 10.33.1.2
 Link Data: 10.33.1.1
 Flags: 0x60 (-|V|L|-|-|-|-)
 MT-ID: 0
 Weight: 0
 SID: 24320

LS age: 489
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 8.0.39.35 (Area-Local Opaque-Type/ID)
 Opaque Type: 8
 Opaque ID: 10019
 Advertising Router: 10.0.1.1
 LS Seq Number: 80000001
 Checksum: 0x4bfc
 Length: 52

Link Type: 2
 Link ID: 10.33.1.2
 Link Data: 10.33.1.2
 Flags: 0x60 (-|V|L|-|-|-|-)
 MT-ID: 0
 Weight: 0
 NBR ID: 10.0.1.33
 SID: 24322

PE1#show ip ospf database opaque-area 7.0.0.0

OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 685
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
 Opaque Type: 7
 Opaque ID: 0
 Advertising Router: 10.0.1.1
 LS Seq Number: 80000001
 Checksum: 0x7ddc
 Length: 44

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

LS age: 615
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x77f4
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

LS age: 809
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x94d6
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 565
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
```

```

Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 473
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

```

The command below displays the database details where an adjacency SID is advertised through opaque LSAs.

```

PE1#show ip ospf database opaque-area 8.0.39.20

      OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)

      Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 766
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x0fb0
Length: 48

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320

LS age: 765
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8

```

```
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x1588
Length: 52
```

```
Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.1
SID: 24320
```

```
PE1#show ip ospf database opaque-area 8.0.39.35
```

```
OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)
```

```
Area-Local Opaque-LSA (Area 0.0.0.0)
```

```
LS age: 649
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.35 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10019
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x4bfc
Length: 52
```

```
Link Type: 2
Link ID: 10.33.1.2
Link Data: 10.33.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.33
SID: 24322
```

```
PE1#show ip ospf database opaque-area 8.0.39.22
```

```
OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)
```

```
Area-Local Opaque-LSA (Area 0.0.0.0)
```

```
LS age: 734
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x3089
Length: 48
```

```
Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24321
```

```
LS age: 733
```

```
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x5e39
Length: 52
```

```
Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 10.0.1.2
SID: 24321
```

The command below on R1 displays who is advertising the prefix SID.

```
PE1#show ip ospf segment-routing announce-list
-----
Area 0.0.0.0
Instance 0
-----
Prefix:10.0.1.11/32
Origin Adv-Router:10.0.1.11
Route-Type:1
-----
```

To verify the SID range through opaque LSAs, use the `show ip ospf database opaque-area 4.0.0.0` command. The command displays the SID range and the base SID as well as the LSA details.

```
PE1#show ip ospf database opaque-area 4.0.0.0

OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 730
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xac29
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 643
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
```



```
LS Seq Number: 80000001
Checksum: 0xa62e
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 819
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x705b
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 575
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 482
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
PE1#show ip ospf database
```

```
OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)
```

```
Router Link States (Area 0.0.0.0)
```

Link ID	ADV Router	Age	Seq#	CkSum	Link count
10.0.1.1	10.0.1.1	509	0x8000000b	0xf736	4
10.0.1.2	10.0.1.2	396	0x80000008	0xa56d	4
10.0.1.11	10.0.1.11	577	0x80000007	0x5a11	3

```

10.0.1.33      10.0.1.33      405      0x80000006 0x1f5d 3
10.0.1.44      10.0.1.44      395      0x80000004 0x3014 3

```

Net Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum
10.1.1.1	10.0.1.1	580	0x80000001	0x7397
10.11.1.1	10.0.1.11	671	0x80000001	0x15d8
10.11.2.1	10.0.1.11	577	0x80000001	0x18d3
10.33.1.2	10.0.1.1	509	0x80000001	0x9b2f
10.33.44.1	10.0.1.33	405	0x80000001	0xe56f
10.44.2.2	10.0.1.2	396	0x80000001	0xaa07

Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	10.0.1.1	578	0x80000004	0x18fb	1
1.0.0.1	10.0.1.2	576	0x80000003	0x1ef4	1
1.0.0.1	10.0.1.11	575	0x80000004	0x40bf	1
1.0.0.1	10.0.1.33	403	0x80000003	0x9a3a	1
1.0.0.1	10.0.1.44	395	0x80000003	0xc6f7	1
1.0.0.12	10.0.1.1	670	0x80000001	0xc46b	12
1.0.0.12	10.0.1.11	669	0x80000001	0x6abc	12
1.0.0.16	10.0.1.2	576	0x80000001	0xc860	16
1.0.0.16	10.0.1.11	575	0x80000001	0x74ac	16
1.0.0.30	10.0.1.1	578	0x80000001	0x1023	30
1.0.0.30	10.0.1.2	579	0x80000001	0x2809	30
1.0.0.32	10.0.1.44	395	0x80000001	0x5953	32
1.0.0.34	10.0.1.2	394	0x80000001	0x6073	34
1.0.0.36	10.0.1.33	403	0x80000001	0x87ee	36
1.0.0.36	10.0.1.44	404	0x80000001	0x6307	36
1.0.0.40	10.0.1.33	508	0x80000001	0x07c0	40
1.0.0.42	10.0.1.1	507	0x80000001	0xd113	42
4.0.0.0	10.0.1.1	675	0x80000001	0xac29	0
4.0.0.0	10.0.1.2	588	0x80000001	0xa62e	0
4.0.0.0	10.0.1.11	764	0x80000001	0x705b	0
4.0.0.0	10.0.1.33	520	0x80000001	0xebc9	0
4.0.0.0	10.0.1.44	428	0x80000001	0xa901	0
7.0.0.0	10.0.1.1	640	0x80000001	0x7ddc	0
7.0.0.0	10.0.1.2	570	0x80000001	0x77f4	0
7.0.0.0	10.0.1.11	764	0x80000001	0x94d6	0
7.0.0.0	10.0.1.33	520	0x80000001	0x1b60	0
7.0.0.0	10.0.1.44	428	0x80000001	0x6514	0
8.0.39.20	10.0.1.1	670	0x80000001	0x0fb0	10004
8.0.39.20	10.0.1.11	669	0x80000001	0x1588	10004
8.0.39.22	10.0.1.2	576	0x80000001	0x3089	10006
8.0.39.22	10.0.1.11	575	0x80000001	0x5e39	10006
8.0.39.29	10.0.1.1	578	0x80000001	0x1d93	10013
8.0.39.29	10.0.1.2	579	0x80000001	0x9534	10013
8.0.39.30	10.0.1.44	395	0x80000001	0x7ec6	10014
8.0.39.31	10.0.1.2	394	0x80000001	0x0c1c	10015
8.0.39.32	10.0.1.33	403	0x80000001	0xc10b	10016
8.0.39.32	10.0.1.44	404	0x80000001	0x0df8	10016
8.0.39.34	10.0.1.33	508	0x80000001	0x283d	10018
8.0.39.35	10.0.1.1	507	0x80000001	0x4bfc	10019

Segment Routing MPLS OAM

Segment Routing Operations, Administration, and Maintenance (OAM) helps service providers to monitor label-switched paths (LSPs) and quickly isolate forwarding problems to assist with fault detection and troubleshooting in the network.

The Segment Routing OAM feature provides support for FEC (forwarding equivalence classes) LSP Ping and Traceroute, IGP prefix SID FEC type, and partially IGP adjacency-SID FEC.

The following are the main benefits of Segment Routing-OAM Support:

- Operations: Network monitoring and fault management.
- Administration: Network discovery and planning.
- Maintenance: Corrective and preventive activities, minimize occurrences and impact of failures.

Segment Routing Ping

The MPLS LSP ping feature is used to check the connectivity between ingress and egress of LSP. MPLS LSP ping uses MPLS echo request and reply messages, similar to Internet Control Message Protocol (ICMP) echo request and reply messages, to validate an LSP.

Segment routing ping is an extension of the MPLS LSP ping to perform the connectivity verification on the segment routing control plane.

Segment Routing ping can use either generic FEC type or SR control-plane FEC type (ISIS-SR or OSPF-SR)

Segment Routing Traceroute

The MPLS LSP traceroute is used to isolate the failure point of an LSP. It is used for hop-by-hop fault localization and path tracing. The MPLS LSP traceroute feature relies on the expiration of the Time to Live (TTL) value of the packet that carries the echo request.

Similar to segment routing ping, you can initiate the segment routing traceroute operation only when Segment Routing control plane is available at the originator

Segment Routing traceroute can use either generic FEC type or SR control-plane FEC type (OSPF-SR or ISIS-SR).

Kindly refer [Figure 17](#)

Validation

These examples show how to use segment routing ping to test the connectivity of a segment routing control plane and segment routing trace to trace LSP of specified Prefix SID.

Ping with other options

Validation on Ping with other options

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32
Sending 5 MPLS Echos to 2.32.0.0, 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)
```

Detail

Validation on Detail

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 1.10 ms
! seq_num = 2 10.0.1.33 0.61 ms
! seq_num = 3 10.0.1.33 0.58 ms
! seq_num = 4 10.0.1.33 0.59 ms
! seq_num = 5 10.0.1.33 0.58 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.58/0.84/1.10
```

Destination

Validation on Destination

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 destination 127.1.0.1 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 0.69 ms
! seq_num = 2 10.0.1.33 0.61 ms
! seq_num = 3 10.0.1.33 0.45 ms
! seq_num = 4 10.0.1.33 0.56 ms
! seq_num = 5 10.0.1.33 0.52 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.45/0.57/0.69
```

Source

Validation on Source

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 source 10.0.1.11
Sending 5 MPLS Echos to 2.32.0.0, 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)

Flags

Validation on Flags

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 destination 127.1.0.1 flags detail  
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 0.63 ms  
! seq_num = 2 10.0.1.33 0.58 ms  
! seq_num = 3 10.0.1.33 0.65 ms  
! seq_num = 4 10.0.1.33 0.56 ms  
! seq_num = 5 10.0.1.33 0.56 ms
```

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.56/0.61/0.65

Timeout

Validation on Timeout

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 timeout 500 detail  
Sending 5 MPLS Echos to 10.0.1.33, timeout is 500 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 10.0.1.33 0.89 ms  
! seq_num = 2 10.0.1.33 0.61 ms  
! seq_num = 3 10.0.1.33 0.59 ms  
! seq_num = 4 10.0.1.33 0.62 ms  
! seq_num = 5 10.0.1.33 0.63 ms
```

```
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.59/0.74/0.89
```

Force-explicit-null

Validation on Force-explicit-null

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 force-explicit-null detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 0.81 ms
! seq_num = 2 10.0.1.33 0.54 ms
! seq_num = 3 10.0.1.33 0.51 ms
! seq_num = 4 10.0.1.33 0.57 ms
! seq_num = 5 10.0.1.33 0.74 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.51/0.66/0.81
```

Reply-mode

Validation on Reply-mode

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 reply-mode 2 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 0.91 ms
! seq_num = 2 10.0.1.33 0.73 ms
! seq_num = 3 10.0.1.33 0.62 ms
! seq_num = 4 10.0.1.33 0.70 ms
! seq_num = 5 10.0.1.33 0.57 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.57/0.74/0.91
```

Repeat

Validation on Repeat

```
PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 repeat 5 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 0.80 ms
! seq_num = 2 10.0.1.33 0.71 ms
! seq_num = 3 10.0.1.33 0.58 ms
! seq_num = 4 10.0.1.33 0.56 ms
! seq_num = 5 10.0.1.33 0.54 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.54/0.67/0.80

```

Interval

Validation on Interval

```

PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 interval 10 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 0.74 ms
! seq_num = 2 10.0.1.33 0.62 ms
! seq_num = 3 10.0.1.33 0.56 ms
! seq_num = 4 10.0.1.33 0.62 ms
! seq_num = 5 10.0.1.33 0.64 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.56/0.65/0.74

```

TTL

Validation on TTL

```

PE1#ping mpls ospf-sr ipv4 10.0.1.33/32 ttl 225 detail
Sending 5 MPLS Echos to 10.0.1.33, 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 10.0.1.33 0.76 ms
! seq_num = 2 10.0.1.33 0.67 ms
! seq_num = 3 10.0.1.33 0.70 ms
! seq_num = 4 10.0.1.33 0.64 ms
! seq_num = 5 10.0.1.33 0.51 ms
```

```
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.51/0.63/0.76
```

Trace with other options

Details

Validation on Details

```
PE1#trace mpls ospf-sr ipv4 10.0.1.33/32 detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels: 4 16700]
R 1 10.0.1.1 [Labels: 16700] 0.94 ms
R 2 10.0.1.3 [Labels: 16700] 0.99 ms
! 3 10.0.1.33 0.77 ms
```

Destination

Validation on Destination

```
PE1#trace mpls ospf-sr ipv4 10.0.1.33/32 destination 127.1.0.1 detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels: 4 16700]
R 1 10.0.1.1 [Labels: 16700] 0.82 ms
R 2 10.0.1.3 [Labels: 16700] 0.84 ms
! 3 10.0.1.33 0.84 ms
```

Source

Validation on Source

```
PE1#trace mpls ospf-sr ipv4 10.0.1.33/32 destination 127.1.0.1 source 10.0.1.11 detail
```



```
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels:  4 16700]
R 1 10.0.1.1 [Labels: 16700] 0.88 ms
R 2 10.0.1.3 [Labels: 16700] 0.91 ms
! 3 10.0.1.33 0.57 ms
```

Flags

Validation on Flags

```
PE1#trace mpls ospf-sr ipv4 10.0.1.33/32 flags detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels:  4 16700]
R 1 10.0.1.1 [Labels: 16700] 0.85 ms
R 2 10.0.1.3 [Labels: 16700] 0.90 ms
! 3 10.0.1.33 0.56 ms
```

Reply mode

Validation on Reply mode

```
PE1#trace mpls ospf-sr ipv4 10.0.1.33/32 reply-mode 2 detail
Tracing MPLS Label Switched Path to 10.0.1.33, 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 10.11.1.1 [Labels:  4 16700]
R 1 10.0.1.1 [Labels: 16700] 0.82 ms
R 2 10.0.1.3 [Labels: 16700] 0.91 ms
! 3 10.0.1.33 0.66 ms
```

Timeout

Validation on Timeout

```
PE1#trace mpls ospf-sr ipv4 10.0.1.33/32 timeout 300 detail
Tracing MPLS Label Switched Path to 10.0.1.33, timeout is 300 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 10.11.1.1 [Labels: 4 16700]
R 1 10.0.1.1 [Labels: 16700] 0.94 ms
R 2 10.0.1.3 [Labels: 16700] 0.90 ms
! 3 10.0.1.33 0.70 ms
```

Configuring OSPF Inter-Area Segment Routing

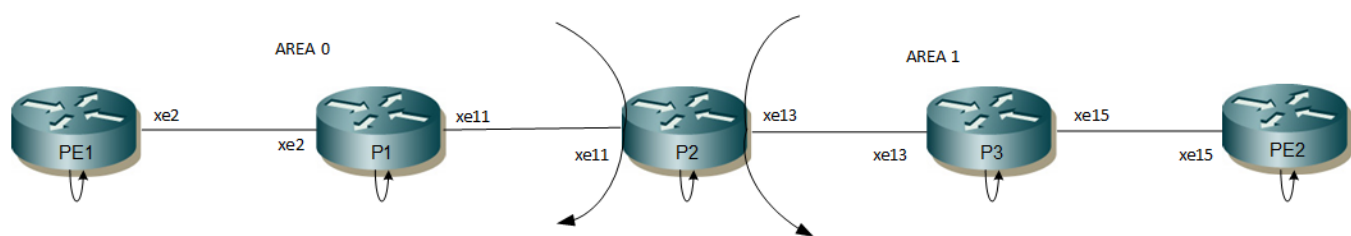
This section shows how to configure segment routing between routers in different areas.

Topology

In the topology in [Figure 18](#):

- Router 1 and router 2 are in backbone area 0
- Router 3 is an area border router (ABR) connected to both areas 0 and area 1
- Router 4 is in area 1

Figure 18. OSPF Inter-Area Segment Routing Topology



Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1(config)#int lo	Enter interface mode.
PE1(config-if)#ip address 10.0.1.11/32 secondary	Configure the IP address of the interface.
PE1(config-if)# prefix-sid absolute 16000 no-php	Assign the Prefix SID value.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#int xe2	Enter interface mode.
PE1(config-if)#ip address 10.11.1.1/30	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router ospf 1	Configure the routing process and specify the Process ID (1).

PE1(config-router)#router-id 10.0.1.11	Advertise the router-id
PE1(config-router)#network 10.0.1.11/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
PE1(config-router)#network 10.11.1.0/30 area 0.0.0.0	Advertise the xe2 interface in OSPF area 0.
PE1(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range.
PE1(config-router)# segment-routing mpls	Enable Segment Routing for the OSPF process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration.

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#int lo	Enter interface mode.
P1(config-if)#ip address 10.0.1.1/32 secondary	Configure the IP address of the interface.
P1(config-if)# prefix-sid index 1000 no-php	Assign the Prefix SID value.
P1(config-if)#exit	Exit interface mode.
P1(config)#int xe2	Enter interface mode.
P1(config-if)#ip address 10.11.1.2/30	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#int xe11	Enter interface mode.
P1(config-if)#ip address 10.1.1.1/30	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
P1(config-router)#router-id 10.0.1.1	Advertise the router-id
P1(config-router)#network 10.0.1.1/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
P1(config-router)#network 10.11.1.0/30 area 0.0.0.0	Advertise the xe2 interface in OSPF area 0.
P1(config-router)#network 10.1.1.0/30 area 0.0.0.0	Advertise the xe11 interface in OSPF area 0.
P1(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range.

P1(config-router)# segment-routing mpls	Enable Segment Routing for the OSPF process.
P1(config-router)#exit	Exit router mode.
P1(config)#commit	Commit the candidate configuration to the running configuration.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#int xe11	Enter interface mode.
P2(config-if)#ip address 10.1.1.2/30	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable Label Switching
P2(config-if)#exit	Exit interface mode.
P2(config)#int xe13	Enter interface mode.
P2(config-if)#ip address 10.44.2.2/30	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#int lo	Enter interface mode.
P2(config-if)#ip address 10.0.1.2/32 secondary	Configure the IP address in the loopback interface
P2(config-if)#prefix-sid index 2000 no-php	Set the prefix SID value.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
P2(config-router)#router-id 10.0.1.2	Advertise the router-id
P2(config-router)#network 10.0.1.2/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
P2(config-router)#network 10.44.2.0/30 area 1	Advertise the xe13 interface in OSPF area 1.
P2(config-router)#network 10.1.1.0/30 area 0	Advertise the xe11 interface in OSPF area 0.
P2(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range.
P2(config-router)#segment-routing mpls	Enable Segment Routing for the OSPF process.
P2(config-router)#exit	Exit router mode.
P2(config)#commit	Commit the candidate configuration to the running configuration.

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#int xe13	Enter interface mode.
P3(config-if)#ip address 10.44.2.1/30	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#int xe15	Enter interface mode.
P3(config-if)#ip address 10.33.44.2/30	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable Label Switching
P3(config-if)#exit	Exit interface mode.
P3(config)#int lo	Enter interface mode.
P3(config-if)#ip address 10.0.1.44/32 secondary	Configure the IP address in the loopback interface
P3(config-if)#prefix-sid absolute 20000 no- php	Set the prefix SID value.
P3(config-if)#exit	Exit interface mode.
P3(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
P3(config-router)#router-id 10.0.1.44	Advertise the router-id
P3(config-router)#network 10.0.1.44/32 area 1	Advertise the lo interface in OSPF area 1.
P3(config-router)#network 10.44.2.0/30 area 1	Advertise the xe13 interface in OSPF area 1.
P3(config-router)#network 10.33.44.2/30 area 1	Advertise the xe15 interface in OSPF area 1.
P3(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range.
P3(config-router)#segment-routing mpls	Enable Segment Routing for the OSPF process.
P3(config-router)#exit	Exit router mode.
P3(config)#commit	Commit the candidate configuration to the running configuration.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#int xe15	Enter interface mode.
PE2(config-if)#ip address 10.33.44.1/30	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.

PE2(config)#int lo	Enter interface mode.
PE2(config-if)#ip address 10.0.1.33/32 secondary	Configure the IP address of the interface.
PE2(config-if)# prefix-sid absolute 19000 no-php	Assign the Prefix SID value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router ospf 1	Configure the routing process and specify the Process ID (1).
PE2(config-router)#router-id 10.0.1.33	Advertise the router-id
PE2(config-router)#network 10.33.44.0/30 area 1	Advertise the xe15 interface in OSPF area 1.
PE2(config-router)#network 10.0.1.33/32 area 1	Advertise the lo interface in OSPF area 1.
PE2(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range.
PE2(config-router)# segment-routing mpls	Enable Segment Routing for the OSPF process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration.

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
10.0.1.1       1     Full/Backup     00:00:32   10.11.1.2   xe2           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
10.0.1.2       1     Full/Backup     00:00:29   10.1.1.2    xe11          0
10.0.1.11      1     Full/DR         00:00:38   10.11.1.1   xe2           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
10.0.1.1       1     Full/DR         00:00:30   10.1.1.1    xe11          0
10.0.1.44      1     Full/Backup     00:00:30   10.44.2.1   xe13          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
10.0.1.44      1      Full/DR        00:00:37    10.33.44.2   xe15          0

P3#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
10.0.1.33      1      Full/Backup    00:00:33    10.33.44.1   xe15          0
10.0.1.2       1      Full/DR        00:00:32    10.44.2.2    xe13          0

```

Validation 2

Verify that segment routing is enabled and that prefix SIDs are announced to other routers via OSPF opaque LSAs. Verify that labels are in the MPLS forwarding table and that prefix SIDs are installed. Verify the same in FTN and ILM tables. For a penultimate hop, label 3 is installed in forwarding tables.

Use `show mpls forwarding-table` to verify that Configured Prefix SIDs can be seen in the ILM table in the label field. Use `show mpls ilm-table` to verify the same.

For prefix advertisement, if “Route type” is 1, then it is intra-area; if it is 3, then the prefix SID is belongs to the inter-area. Verify the same using `show ip ospf segment-routing announce-list`.

To verify prefix-sid advertisement through opaque LSAs, use `show ip ospf database opaque-area 7.0.0.1`.

PE1 in Backbone Area 0

Validation on PE1 Router in Backbone Area 0

```

PE1#show mpls forwarding-tableCodes: > - 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: Disabled
Code   FEC          Nextthop   FTN-ID   Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC
O> 10.0.1.1/32  0          1         10        -          -     -          -
-                                     00:35:00  9        0        Yes  17000     xe2      No
10.11.1.2 -          -          -         -          -          -     -          -
O> 10.0.1.2/32  0          2         13        -          -     -          -
-                                     00:28:13  12       0        Yes  18000     xe2      No
10.11.1.2 -          -          -         -          -          -     -          -
O> 10.0.1.33/32 0          3         16        -          -     -          -
-                                     00:28:13  15       0        Yes  19000     xe2      No
10.11.1.2 -          -          -         -          -          -     -          -
O> 10.0.1.44/32 0          4         19        -          -     -          -
-                                     00:28:13  18       0        Yes  20000     xe2      No
10.11.1.2 -          -          -         -          -          -     -          -

```


Validation on PE1 Router MPLS ftn-table

```

PE1#show mpls ftn-table
Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 17000
Nexthop addr: 10.11.1.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 18000
Nexthop addr: 10.11.1.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 7
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 19000
Nexthop addr: 10.11.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 20000
Nexthop addr: 10.11.1.2 cross connect ix: 3, 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
O> 10.0.1.2/32 3 18000 18000 N/A xe2 10.11
.1.2 LSP_DEFAULT
O> 10.0.1.1/32 2 17000 17000 N/A xe2 10.11
.1.2 LSP_DEFAULT
O> 10.0.1.11/32 1 16000 Nolabel N/A N/A 127.0
.0.1 LSP_DEFAULT
O> 10.0.1.44/32 4 20000 20000 N/A xe2 10.11
.1.2 LSP_DEFAULT
O> 10.0.1.33/32 5 19000 19000 N/A xe2 10.11
.1.2 LSP_DEFAULT
O> 10.11.1.2/32 6 24320 3 N/A xe2 10.11
.1.2 LSP_DEFAULT

PE1#show mpls in-segment-table
Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 3
Cross connect ix: 2, in intf: - in label: 18000 out-segment ix: 3

```

```

Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 18000
Nexthop addr: 10.11.1.2          cross connect ix: 2, op code: Swap

```

```

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.1/32, ILM-ID: 2
Cross connect ix: 1, in intf: - in label: 17000 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 17000
Nexthop addr: 10.11.1.2          cross connect ix: 1, op code: Swap

```

```

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 1
Cross connect ix: 1, in intf: - in label: 16000 out-segment ix: 0
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
Nexthop addr: 127.0.0.1          cross connect ix: 1, op code: Pop

```

```

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.44/32, ILM-ID: 4
Cross connect ix: 3, in intf: - in label: 20000 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 20000
Nexthop addr: 10.11.1.2          cross connect ix: 3, op code: Swap

```

```

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 5
Cross connect ix: 4, in intf: - in label: 19000 out-segment ix: 7
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 19000
Nexthop addr: 10.11.1.2          cross connect ix: 4, op code: Swap

```

```

Owner: OSPF-SR, # of pops: 1, fec: 10.11.1.2/32, ILM-ID: 6
Cross connect ix: 5, in intf: - in label: 24320 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: 10.11.1.2          cross connect ix: 5, op code: Swap

```

Validation on PE1 Router MPLS out-segment-table

```

PE1#show mpls out-segment-table
Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 18000
Nexthop addr: 10.11.1.2          cross connect ix: 2, op code: Push

Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 17000
Nexthop addr: 10.11.1.2          cross connect ix: 1, op code: Push

Out-segment with ix: 9, owner: N/A, Stale: NO, out intf: xe2, out label: 3
Nexthop addr: 10.11.1.2          cross connect ix: 5, op code: Push

Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 20000
Nexthop addr: 10.11.1.2          cross connect ix: 3, op code: Push

Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 19000
Nexthop addr: 10.11.1.2          cross connect ix: 4, op code: Push

PE1#show ip ospf database opaque-area self-originate

OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

```

```

LS age: 661
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x46bc
Length: 28

MPLS TE router ID : 10.0.1.11

Number of Links : 0

LS age: 661
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x6abc
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 981
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x6e5c
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 151
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x92d7
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 671
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x1389
Length: 52

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.1
SID: 24320

PE1#sh ip ospf database opaque-area

      OSPF Router with ID (10.0.1.11) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 661
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000005
Checksum: 0x16fc
Length: 28

MPLS TE router ID : 10.0.1.1

Number of Links : 0

LS age: 254
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000004
Checksum: 0x1cf5
Length: 28

MPLS TE router ID : 10.0.1.2

Number of Links : 0

```

```

LS age: 650
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x46bc
Length: 28

```

MPLS TE router ID : 10.0.1.11

Number of Links : 0

```

LS age: 1895
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000003
Checksum: 0x9a3a
Length: 28

```

MPLS TE router ID : 10.0.1.33

Number of Links : 0

```

LS age: 1887
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
Checksum: 0xc6f7
Length: 28

```

MPLS TE router ID : 10.0.1.44

Number of Links : 0

```

LS age: 652
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0xc06d
Length: 108

```

Link connected to Broadcast network

Link ID : 10.11.1.1

Interface Address : 10.11.1.2

Admin Metric : 1

Maximum bandwidth : 10000000.00 Kbits/s

Maximum reservable bandwidth : 10000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s

Priority 1 : 10000000.00 Kbits/s

Priority 2 : 10000000.00 Kbits/s

Priority 3 : 10000000.00 Kbits/s

Priority 4 : 10000000.00 Kbits/s

Priority 5 : 10000000.00 Kbits/s

Priority 6 : 10000000.00 Kbits/s

Priority 7 : 10000000.00 Kbits/s

```
Number of Links : 1

LS age: 650
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x6abc
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 694
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x0e24
Length: 108

Link connected to Broadcast network
Link ID : 10.1.1.1
Interface Address : 10.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 604
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x260a
Length: 108

Link connected to Broadcast network
Link ID : 10.1.1.1
```

```
Interface Address : 10.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1887
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1895
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x87ee
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.1
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 584
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
```

```
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000002
Checksum: 0x6108
Length: 108
```

```
Link connected to Broadcast network
```

```
Link ID : 10.33.44.1
Interface Address : 10.33.44.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

```
Number of Links : 1
```

```
LS age: 504
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0xaa2a
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 4
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0xa42f
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 969
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x6e5c
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
```



```
Algorithm: 0

LS age: 2012
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 1920
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 524
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x7bdd
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

LS age: 198
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0x7cd3
Length: 92
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 139
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x92d7
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 2012
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
```

```
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 1920
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

LS age: 661
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0x0bb2
Length: 48

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 660
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x1389
Length: 52

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.1
SID: 24320
```

```
LS age: 904
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x1b94
Length: 52
```

```
Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
SID: 24321
```

```
LS age: 2071
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x9534
Length: 48
```

```
Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320
```

```
LS age: 1887
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x7ec6
Length: 48
```

```
Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24321
```

```
LS age: 1895
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
```

Checksum: 0xc10b

Length: 52

Link Type: 2

Link ID: 10.33.44.1

Link Data: 10.33.44.1

Flags: 0x60 (-|V|L|-|-|-|-|-)

MT-ID: 0

NBR ID: 10.0.1.44

SID: 24321

LS age: 1896

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)

Opaque Type: 8

Opaque ID: 10016

Advertising Router: 10.0.1.44

LS Seq Number: 80000001

Checksum: 0x0df8

Length: 48

Link Type: 2

Link ID: 10.33.44.1

Link Data: 10.33.44.2

Flags: 0x60 (-|V|L|-|-|-|-|-)

MT-ID: 0

SID: 24320

PE1#show ip ospf segment-routing announce-list

Area 0.0.0.0

Instance 0

Prefix:10.0.1.11/32

Origin Adv-Router:10.0.1.11

Route-Type:1

PE1#show ip ospf segment-routing capability

OSPF process 1:

Advertisement Router Capability	:10.0.1.1
---------------------------------	-----------

Algorithm	:0
-----------	----

SRMS Preference	:0
-----------------	----

Total SID'S Supported	:8000
-----------------------	-------

SID Range List Count	:1
----------------------	----

SID's Range	:16000 - 23999
-------------	----------------

Advertisement Router Capability	:10.0.1.2
---------------------------------	-----------

Algorithm	:0
-----------	----

SRMS Preference	:0
-----------------	----

Total SID'S Supported	:8000
-----------------------	-------

SID Range List Count	:1
----------------------	----

SID's Range	:16000 - 23999
-------------	----------------

Advertisement Router Capability	:10.0.1.11
---------------------------------	------------

Algorithm	:0
-----------	----

SRMS Preference	:0
-----------------	----

Total SID'S Supported	:8000
-----------------------	-------

SID Range List Count	:1
----------------------	----

SID's Range	:16000 - 23999
-------------	----------------

Advertisement Router Capability	:10.0.1.33
---------------------------------	------------

Algorithm	:0
-----------	----

SRMS Preference	:0
-----------------	----

```

Total SID'S Supported      :8000
SID Range List Count      :1
SID's Range               :16000 - 23999
-----
Advertisement Router Capability :10.0.1.44
Algorithm                 :0
SRMS Preference           :0
Total SID'S Supported      :8000
SID Range List Count      :1
SID's Range               :16000 - 23999
-----

P1 in Backbone Area 0
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, SR: Disabled
Code   FEC          FTN-ID   Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC          Nexthop   Algo-Num  UpTime
O>    10.0.1.2/32    2         14        -          -    -         -
      -             -         0         00:28:25
o      10.1.1.2      -         13        0          Yes   18000      xe11      N
O>    10.0.1.11/32   1         9         -          -    -         -
      -             -         0         00:35:12
o      10.1.1.1      -         8         0          Yes   16000      xe2       No
O>    10.0.1.33/32   3         17        -          -    -         -
      -             -         0         00:28:25
o      10.1.1.2      -         16        0          Yes   19000      xe11      N
O>    10.0.1.44/32   -         20        -          -    -         -
      -             -         0         00:28:25
o      10.1.1.2      -         19        0          Yes   20000      xe11      N

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
O>    10.0.1.2/32    5         18000     18000     N/A      xe11      10.1.
1.2    LSP_DEFAULT
O>    10.0.1.1/32    3         17000     Nolabel   N/A      N/A      127.0
.0.1   LSP_DEFAULT
O>    10.0.1.11/32   2         16000     16000     N/A      xe2      10.11
.1.1   LSP_DEFAULT
O>    10.11.1.1/32   6         24320     3         N/A      xe2      10.11
.1.1   LSP_DEFAULT
O>    10.0.1.44/32   1         20000     20000     N/A      xe11     10.1.
1.2    LSP_DEFAULT
O>    10.0.1.33/32   7         19000     19000     N/A      xe11     10.1.
1.2    LSP_DEFAULT
O>    10.1.1.2/32    4         24321     3         N/A      xe11     10.1.
1.2    LSP_DEFAULT

```

Validation on P1 Router MPLS ftn-table

```
P1#show mpls ftn-table
```

```
Primary FTN entry with FEC: 10.0.1.2/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 18000
Nexthop addr: 10.1.1.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 16000
Nexthop addr: 10.11.1.1 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 9
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 19000
Nexthop addr: 10.1.1.2 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 20000
Nexthop addr: 10.1.1.2 cross connect ix: 1, op code: Push

P1#show mpls in-segment-table
Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 5
Cross connect ix: 4, in intf: - in label: 18000 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 18000
Nexthop addr: 10.1.1.2 cross connect ix: 4, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.1/32, ILM-ID: 3
Cross connect ix: 1, in intf: - in label: 17000 out-segment ix: 0
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
Nexthop addr: 127.0.0.1 cross connect ix: 1, op code: Pop

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 2
Cross connect ix: 2, in intf: - in label: 16000 out-segment ix: 3
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 16000
Nexthop addr: 10.11.1.1 cross connect ix: 2, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.11.1.1/32, ILM-ID: 6
Cross connect ix: 5, in intf: - in label: 24320 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: xe2, out label: 3
Nexthop addr: 10.11.1.1 cross connect ix: 5, op code: Swap
```

```

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.44/32, ILM-ID: 1
  Cross connect ix: 1, in intf: - in label: 20000 out-segment ix: 1
    Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 20000
  Nexthop addr: 10.1.1.2      cross connect ix: 1, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 7
  Cross connect ix: 6, in intf: - in label: 19000 out-segment ix: 9
    Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 19000
  Nexthop addr: 10.1.1.2      cross connect ix: 6, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.1.1.2/32, ILM-ID: 4
  Cross connect ix: 3, in intf: - in label: 24321 out-segment ix: 4
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 4, owner: N/A, Stale: NO, out intf: xe11, out label: 3
  Nexthop addr: 10.1.1.2      cross connect ix: 3, op code: Swap

```

Validation on P1 Router MPLS out-segment-table

```

P1#show mpls out-segment-table
  Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe2, out label: 3
  Nexthop addr: 10.11.1.1      cross connect ix: 5, op code: Push

  Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 18000
  Nexthop addr: 10.1.1.2      cross connect ix: 4, op code: Push

  Out-segment with ix: 4, owner: N/A, Stale: NO, out intf: xe11, out label: 3
  Nexthop addr: 10.1.1.2      cross connect ix: 3, op code: Push

  Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 20000
  Nexthop addr: 10.1.1.2      cross connect ix: 1, op code: Push

  Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 19000
  Nexthop addr: 10.1.1.2      cross connect ix: 6, op code: Push

  Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 16000
  Nexthop addr: 10.11.1.1      cross connect ix: 2, op code: Push

P1#show ip ospf database opaque-area self-originate

  OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)

    Area-Local Opaque-LSA (Area 0.0.0.0)

      LS age: 761
      Options: 0x22 (-|-|DC|-|-|E|-)
      LS Type: Area-Local Opaque-LSA
      Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
      Opaque Type: 1
      Opaque ID: 1
      Advertising Router: 10.0.1.1
      LS Seq Number: 80000005
      Checksum: 0x16fc
      Length: 28

      MPLS TE router ID : 10.0.1.1

```



```

Number of Links : 0

LS age: 751
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0xc06d
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 794
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x0e24
Length: 108

Link connected to Broadcast network
Link ID : 10.1.1.1
Interface Address : 10.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 604
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0xaa2a
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

```

```

LS age: 624
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x7bdd
Length: 44

  Prefix type : Extended Prefix TLV
  Route Type: 1
  Prefix Length: 32
  AF: 0
  Flags: 0x40 (-|N|-|-|-|-|-)
  Address Prefix: 10.0.1.1
  Flags: 0x40 (-|NP|-|-|-|-|-)
  MT-ID: 0
  Algorithm: 0
  SID: 1000

LS age: 761
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0x0bb2
Length: 48

  Link Type: 2
  Link ID: 10.11.1.1
  Link Data: 10.11.1.2
  Flags: 0x60 (-|V|L|-|-|-|-)
  MT-ID: 0
  SID: 24320

LS age: 1004
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x1b94
Length: 52

  Link Type: 2
  Link ID: 10.1.1.1
  Link Data: 10.1.1.1
  Flags: 0x60 (-|V|L|-|-|-|-)
  MT-ID: 0
  NBR ID: 10.0.1.2
  SID: 24321

```

```
P1#show ip ospf database opaque-area
```

```
    OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)
```

```
        Area-Local Opaque-LSA (Area 0.0.0.0)
```

```
LS age: 771
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000005
Checksum: 0x16fc
Length: 28
```

MPLS TE router ID : 10.0.1.1

Number of Links : 0

```
LS age: 365
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000004
Checksum: 0x1cf5
Length: 28
```

MPLS TE router ID : 10.0.1.2

Number of Links : 0

```
LS age: 762
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x46bc
Length: 28
```

MPLS TE router ID : 10.0.1.11

Number of Links : 0

```
LS age: 2006
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000003
Checksum: 0x9a3a
Length: 28
```

MPLS TE router ID : 10.0.1.33

Number of Links : 0

```
LS age: 1999
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
```

```

Checksum: 0xc6f7
Length: 28

MPLS TE router ID : 10.0.1.44

Number of Links : 0

LS age: 762
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0xc06d
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 762
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x6abc
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 805
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x0e24

```

Length: 108

Link connected to Broadcast network

Link ID : 10.1.1.1

Interface Address : 10.1.1.1

Admin Metric : 1

Maximum bandwidth : 10000000.00 Kbits/s

Maximum reservable bandwidth : 10000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s

Priority 1 : 10000000.00 Kbits/s

Priority 2 : 10000000.00 Kbits/s

Priority 3 : 10000000.00 Kbits/s

Priority 4 : 10000000.00 Kbits/s

Priority 5 : 10000000.00 Kbits/s

Priority 6 : 10000000.00 Kbits/s

Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 715

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)

Opaque Type: 1

Opaque ID: 30

Advertising Router: 10.0.1.2

LS Seq Number: 80000002

Checksum: 0x260a

Length: 108

Link connected to Broadcast network

Link ID : 10.1.1.1

Interface Address : 10.1.1.2

Admin Metric : 1

Maximum bandwidth : 10000000.00 Kbits/s

Maximum reservable bandwidth : 10000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s

Priority 1 : 10000000.00 Kbits/s

Priority 2 : 10000000.00 Kbits/s

Priority 3 : 10000000.00 Kbits/s

Priority 4 : 10000000.00 Kbits/s

Priority 5 : 10000000.00 Kbits/s

Priority 6 : 10000000.00 Kbits/s

Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1999

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)

Opaque Type: 1

Opaque ID: 32

Advertising Router: 10.0.1.44

LS Seq Number: 80000001

Checksum: 0x5953

Length: 108

Link connected to Broadcast network

Link ID : 10.44.2.2

Interface Address : 10.44.2.1

Admin Metric : 1

Maximum bandwidth : 10000000.00 Kbits/s

Maximum reservable bandwidth : 10000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s

Priority 1 : 10000000.00 Kbits/s

Priority 2 : 10000000.00 Kbits/s

Priority 3 : 10000000.00 Kbits/s

Priority 4 : 10000000.00 Kbits/s

Priority 5 : 10000000.00 Kbits/s

Priority 6 : 10000000.00 Kbits/s

Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

```

LS age: 2006
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x87ee
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.1
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 695
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000002
Checksum: 0x6108
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.1
Interface Address : 10.33.44.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 615
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0xaa2a
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

```

```
LS age: 115
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0xa42f
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 1082
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x6e5c
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 2123
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 2030
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 635
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
```

```
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x7bdd
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000
```

```
LS age: 309
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0x7cd3
Length: 92
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000
```

```
LS age: 252
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
```



```
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x92d7
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 2123
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 2030
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

LS age: 771
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
```

```
LS Seq Number: 80000003
Checksum: 0x0bb2
Length: 48
```

```
Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24320
```

```
LS age: 772
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x1389
Length: 52
```

```
Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.1
SID: 24320
```

```
LS age: 1015
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x1b94
Length: 52
```

```
Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
SID: 24321
```

```
LS age: 55
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x9335
Length: 48
```

```
Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
```

```

SID: 24320

LS age: 1999
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x7ec6
Length: 48

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24321

LS age: 2006
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xc10b
Length: 52

Link Type: 2
Link ID: 10.33.44.1
Link Data: 10.33.44.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.44
SID: 24321

LS age: 2006
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x0df8
Length: 48

Link Type: 2
Link ID: 10.33.44.1
Link Data: 10.33.44.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

Pl#show ip ospf database opaque-area 7.0.0.0

      OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 646

```

```
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x7bdd
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000
```

```
LS age: 319
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0x7cd3
Length: 92
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000
```

```
LS age: 262
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
```

```

Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x92d7
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

```

```

LS age: 2133
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

```

```

LS age: 2041
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

```

Validation on P2: ABR Connected to Area 0 and Area 1

```
P2#show ip ospf database
```

OSPF Router with ID (10.0.1.2) (Process ID 1 VRF default)

Router Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Link count
10.0.1.1	10.0.1.1	842	0x80000010	0x771e	3
10.0.1.2	10.0.1.2	688	0x8000000e	0x5879	2
10.0.1.11	10.0.1.11	843	0x8000000e	0x5b49	2
10.0.1.33	10.0.1.33	857	0x80000007	0x7274	2
10.0.1.44	10.0.1.44	2071	0x80000004	0x3014	3

Net Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum
10.1.1.1	10.0.1.1	2257	0x80000001	0x7397
10.11.1.1	10.0.1.11	848	0x80000002	0x13d9
10.33.44.1	10.0.1.33	2081	0x80000001	0xe56f

Summary Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Route
10.0.1.33	10.0.1.2	382	0x80000001	0x619f	10.0.1.33/32
10.0.1.44	10.0.1.2	454	0x80000001	0xe80e	10.0.1.44/32
10.33.44.0	10.0.1.2	454	0x80000001	0x28b1	10.33.44.0/30
10.44.2.0	10.0.1.2	688	0x80000001	0x6990	10.44.2.0/30

Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	10.0.1.1	845	0x80000005	0x16fc	1
1.0.0.1	10.0.1.2	437	0x80000004	0x1cf5	1
1.0.0.1	10.0.1.11	836	0x80000001	0x46bc	1
1.0.0.1	10.0.1.33	2080	0x80000003	0x9a3a	1
1.0.0.1	10.0.1.44	2071	0x80000003	0xc6f7	1
1.0.0.12	10.0.1.1	836	0x80000003	0xc06d	12
1.0.0.12	10.0.1.11	836	0x80000001	0x6abc	12
1.0.0.30	10.0.1.1	879	0x80000002	0x0e24	30
1.0.0.30	10.0.1.2	787	0x80000002	0x260a	30
1.0.0.32	10.0.1.44	2071	0x80000001	0x5953	32
1.0.0.36	10.0.1.33	2080	0x80000001	0x87ee	36
1.0.0.36	10.0.1.44	767	0x80000002	0x6108	36
4.0.0.0	10.0.1.1	689	0x80000002	0xaa2a	0
4.0.0.0	10.0.1.2	187	0x80000002	0xa42f	0
4.0.0.0	10.0.1.11	1155	0x80000002	0x6e5c	0
4.0.0.0	10.0.1.33	2197	0x80000001	0xebc9	0
4.0.0.0	10.0.1.44	2104	0x80000001	0xa901	0
7.0.0.0	10.0.1.1	709	0x80000002	0x7bdd	0
7.0.0.0	10.0.1.2	381	0x80000003	0x7cd3	0
7.0.0.0	10.0.1.11	326	0x80000002	0x92d7	0
7.0.0.0	10.0.1.33	2197	0x80000001	0x1b60	0
7.0.0.0	10.0.1.44	2104	0x80000001	0x6514	0
8.0.39.20	10.0.1.1	845	0x80000003	0x0bb2	10004
8.0.39.20	10.0.1.11	846	0x80000002	0x1389	10004
8.0.39.29	10.0.1.1	1089	0x80000002	0x1b94	10013
8.0.39.29	10.0.1.2	127	0x80000002	0x9335	10013
8.0.39.30	10.0.1.44	2071	0x80000001	0x7ec6	10014
8.0.39.32	10.0.1.33	2080	0x80000001	0xc10b	10016
8.0.39.32	10.0.1.44	2080	0x80000001	0x0df8	10016

Router Link States (Area 0.0.0.1)

Link ID	ADV Router	Age	Seq#	CkSum	Link count
10.0.1.2	10.0.1.2	457	0x80000004	0x5e42	1
10.0.1.33	10.0.1.33	385	0x80000004	0x8e5a	2
10.0.1.44	10.0.1.44	389	0x80000006	0x42fe	3

Net Link States (Area 0.0.0.1)

Link ID	ADV Router	Age	Seq#	CkSum
10.33.44.2	10.0.1.44	389	0x80000001	0x6ddb
10.44.2.2	10.0.1.2	457	0x80000001	0xaa07

Summary Link States (Area 0.0.0.1)

Link ID	ADV Router	Age	Seq#	CkSum	Route
10.0.1.1	10.0.1.2	688	0x80000001	0x9889	10.0.1.1/32
10.0.1.2	10.0.1.2	688	0x80000001	0x849d	10.0.1.2/32
10.0.1.11	10.0.1.2	688	0x80000001	0x3ed8	10.0.1.11/32
10.1.1.0	10.0.1.2	688	0x80000001	0x7aab	10.1.1.0/30
10.11.1.0	10.0.1.2	688	0x80000001	0x0c0f	10.11.1.0/30

Area-Local Opaque-LSA (Area 0.0.0.1)

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	10.0.1.2	455	0x80000002	0x20f3	1
1.0.0.1	10.0.1.33	388	0x80000001	0x9e38	1
1.0.0.1	10.0.1.44	387	0x80000003	0xc6f7	1
1.0.0.32	10.0.1.44	456	0x80000001	0x5953	32
1.0.0.34	10.0.1.2	455	0x80000001	0x6073	34
1.0.0.36	10.0.1.33	388	0x80000001	0x9dd7	36
1.0.0.36	10.0.1.44	387	0x80000001	0x79ef	36
4.0.0.0	10.0.1.2	686	0x80000001	0xa62e	0
4.0.0.0	10.0.1.33	385	0x80000001	0xebc9	0
4.0.0.0	10.0.1.44	448	0x80000001	0xa901	0
7.0.0.0	10.0.1.2	381	0x80000003	0xb912	0
7.0.0.0	10.0.1.33	385	0x80000001	0x1b60	0
7.0.0.0	10.0.1.44	448	0x80000001	0x6514	0
8.0.39.30	10.0.1.44	448	0x80000001	0x61e4	10014
8.0.39.31	10.0.1.2	455	0x80000001	0xea3e	10015
8.0.39.32	10.0.1.33	385	0x80000001	0x4bc5	10016
8.0.39.32	10.0.1.44	387	0x80000001	0x5476	10016

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, (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: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
O>	10.0.1.1/32	3	20	-	-	-	-
	-	-	0	00:28:42			
			19	0	Yes	17000	xe11
No	10.1.1.1	-	-				
O>	10.0.1.11/32	4	23	-	-	-	-
	-	-	0	00:28:42			
			22	0	Yes	16000	xe11
No	10.1.1.1	-	-				
O>	10.0.1.33/32	1	14	-	-	-	-
	-	-	0	00:35:44			
			13	0	Yes	19000	xe13
No	10.44.2.1	-	-				
O>	10.0.1.44/32	2	17	-	-	-	-
	-	-	0	00:35:44			
			16	0	Yes	20000	xe13
No	10.44.2.1	-	-				

P2#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
 none
 Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1

```

Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 17000
Nexthop addr: 10.1.1.1          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0,   Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 16000
Nexthop addr: 10.1.1.1          cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0,   Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 9
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 19000
Nexthop addr: 10.44.2.1        cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0,   Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 20000
Nexthop addr: 10.44.2.1        cross connect ix: 4, op code: Push

```

Validation on P2 Router MPLS ilm-table

```

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
O> 10.0.1.2/32        5        18000      Nolabel     N/A       N/A       127.0
.0.1      LSP_DEFAULT
O> 10.0.1.1/32        1        17000      17000       N/A       xe11      10.1.
1.1      LSP_DEFAULT
O> 10.0.1.11/32       3        16000      16000       N/A       xe11      10.1.
1.1      LSP_DEFAULT
O> 10.1.1.1/32        2        24320      3           N/A       xe11      10.1.
1.1      LSP_DEFAULT
O> 10.0.1.44/32       4        20000      20000       N/A       xe13      10.44
.2.1     LSP_DEFAULT
O> 10.0.1.33/32       7        19000      19000       N/A       xe13      10.44
.2.1     LSP_DEFAULT
O> 10.44.2.1/32       6        24321      3           N/A       xe13      10.44
.2.1     LSP_DEFAULT

```

Validation on P2 Router MPLS in-segment-table

```

P2#show mpls in-segment-table
Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 5
Cross connect ix: 6, in intf: - in label: 18000 out-segment ix: 0

```



```
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
Nexthop addr: 127.0.0.1          cross connect ix: 6, op code: Pop

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.1/32, ILM-ID: 1
Cross connect ix: 1, in intf: - in label: 17000 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 17000
Nexthop addr: 10.1.1.1          cross connect ix: 1, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 3
Cross connect ix: 3, in intf: - in label: 16000 out-segment ix: 4
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 16000
Nexthop addr: 10.1.1.1          cross connect ix: 3, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.1.1.1/32, ILM-ID: 2
Cross connect ix: 2, in intf: - in label: 24320 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: xe11, out label: 3
Nexthop addr: 10.1.1.1          cross connect ix: 2, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.44/32, ILM-ID: 4
Cross connect ix: 4, in intf: - in label: 20000 out-segment ix: 6
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 20000
Nexthop addr: 10.44.2.1          cross connect ix: 4, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 7
Cross connect ix: 6, in intf: - in label: 19000 out-segment ix: 9
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 19000
Nexthop addr: 10.44.2.1          cross connect ix: 6, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.44.2.1/32, ILM-ID: 6
Cross connect ix: 5, in intf: - in label: 24321 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: xe13, out label: 3
Nexthop addr: 10.44.2.1          cross connect ix: 5, op code: Swap

P2#show mpls out-segment-table
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 17000
Nexthop addr: 10.1.1.1          cross connect ix: 1, op code: Push

Out-segment with ix: 4, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 16000
Nexthop addr: 10.1.1.1          cross connect ix: 3, op code: Push

Out-segment with ix: 3, owner: N/A, Stale: NO, out intf: xe11, out label: 3
Nexthop addr: 10.1.1.1          cross connect ix: 2, op code: Push

Out-segment with ix: 6, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 20000
Nexthop addr: 10.44.2.1          cross connect ix: 4, op code: Push

Out-segment with ix: 8, owner: N/A, Stale: NO, out intf: xe13, out label: 3
Nexthop addr: 10.44.2.1          cross connect ix: 5, op code: Push

Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 19000
```

```
Nexthop addr: 10.44.2.1      cross connect ix: 6, op code: Push

P2#show ip ospf database opaque-area

      OSPF Router with ID (10.0.1.2) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 878
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000005
Checksum: 0x16fc
Length: 28

      MPLS TE router ID : 10.0.1.1

      Number of Links : 0

LS age: 469
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000004
Checksum: 0x1cf5
Length: 28

      MPLS TE router ID : 10.0.1.2

      Number of Links : 0

LS age: 869
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x46bc
Length: 28

      MPLS TE router ID : 10.0.1.11

      Number of Links : 0

LS age: 2112
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000003
Checksum: 0x9a3a
Length: 28

      MPLS TE router ID : 10.0.1.33

      Number of Links : 0
```

```

LS age: 2103
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
Checksum: 0xc6f7
Length: 28

MPLS TE router ID : 10.0.1.44

Number of Links : 0

LS age: 869
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0xc06d
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 869
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x6abc
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 911

```

```
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x0e24
Length: 108
```

Link connected to Broadcast network

```
Link ID : 10.1.1.1
Interface Address : 10.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

Number of Links : 1

```
LS age: 819
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x260a
Length: 108
```

Link connected to Broadcast network

```
Link ID : 10.1.1.1
Interface Address : 10.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

Number of Links : 1

```
LS age: 2103
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108
```

Link connected to Broadcast network

```
Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
```

```

Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 2112
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x87ee
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.1
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 800
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000002
Checksum: 0x6108
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.1
Interface Address : 10.33.44.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 721
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1

```

```
LS Seq Number: 80000002
Checksum: 0xaa2a
Length: 44

    Range Size: 8000
    Base-SID: 16000
    Algorithm: 0

LS age: 219
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0xa42f
Length: 44

    Range Size: 8000
    Base-SID: 16000
    Algorithm: 0

LS age: 1187
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x6e5c
Length: 44

    Range Size: 8000
    Base-SID: 16000
    Algorithm: 0

LS age: 2229
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44

    Range Size: 8000
    Base-SID: 16000
    Algorithm: 0

LS age: 2137
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 741
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x7bdd
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

LS age: 413
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0x7cd3
Length: 92

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
```

```
Algorithm: 0
SID: 19000

LS age: 358
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x92d7
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 2229
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 2137
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000
```



```
LS age: 878
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0x0bb2
Length: 48
```

```
Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320
```

```
LS age: 879
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x1389
Length: 52
```

```
Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.1
SID: 24320
```

```
LS age: 1121
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x1b94
Length: 52
```

```
Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
SID: 24321
```

```
LS age: 159
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
```

Checksum: 0x9335
Length: 48

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 2103
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x7ec6
Length: 48

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24321

LS age: 2112
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xc10b
Length: 52

Link Type: 2
Link ID: 10.33.44.1
Link Data: 10.33.44.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.44
SID: 24321

LS age: 2113
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x0df8
Length: 48

Link Type: 2
Link ID: 10.33.44.1
Link Data: 10.33.44.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

```
Area-Local Opaque-LSA (Area 0.0.0.1)

LS age: 487
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x20f3
Length: 28

MPLS TE router ID : 10.0.1.2

Number of Links : 0

LS age: 420
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9e38
Length: 28

MPLS TE router ID : 10.0.1.33

Number of Links : 0

LS age: 419
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
Checksum: 0xc6f7
Length: 28

MPLS TE router ID : 10.0.1.44

Number of Links : 0

LS age: 488
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
```

```

Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 487
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.34 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 34
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6073
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 420
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9dd7
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.2
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 419
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x79ef

```

Length: 108

Link connected to Broadcast network

Link ID : 10.33.44.2

Interface Address : 10.33.44.2

Admin Metric : 1

Maximum bandwidth : 10000000.00 Kbits/s

Maximum reservable bandwidth : 10000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s

Priority 1 : 10000000.00 Kbits/s

Priority 2 : 10000000.00 Kbits/s

Priority 3 : 10000000.00 Kbits/s

Priority 4 : 10000000.00 Kbits/s

Priority 5 : 10000000.00 Kbits/s

Priority 6 : 10000000.00 Kbits/s

Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 718

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)

Opaque Type: 4

Opaque ID: 0

Advertising Router: 10.0.1.2

LS Seq Number: 80000001

Checksum: 0xa62e

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm: 0

LS age: 417

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)

Opaque Type: 4

Opaque ID: 0

Advertising Router: 10.0.1.33

LS Seq Number: 80000001

Checksum: 0xebc9

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm: 0

LS age: 481

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)

Opaque Type: 4

Opaque ID: 0

Advertising Router: 10.0.1.44

LS Seq Number: 80000001

Checksum: 0xa901

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm: 0

LS age: 413

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

```

Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0xb912
Length: 116

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0xc0 (A|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

```

```

LS age: 417
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)

```

```

Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 481
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

LS age: 481
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x61e4
Length: 48

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 487
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.31 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10015
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xea3e
Length: 52

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.44
SID: 24321

LS age: 417

```

```
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x4bc5
Length: 48
```

```
Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24320
```

```
LS age: 419
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5476
Length: 52
```

```
Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.33
SID: 24321
```

P2#show ip ospf database opaque-area self-originate

OSPF Router with ID (10.0.1.2) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

```
LS age: 485
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000004
Checksum: 0x1cf5
Length: 28
```

MPLS TE router ID : 10.0.1.2

Number of Links : 0

```
LS age: 835
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x260a
Length: 108
```



```

Link connected to Broadcast network
Link ID : 10.1.1.1
Interface Address : 10.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

```

Number of Links : 1

```

```

LS age: 235
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0xa42f
Length: 44

```

```

Range Size: 8000
Base-SID: 16000
Algorithm: 0

```

```

LS age: 429
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0x7cd3
Length: 92

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32

```

```

AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 175
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x9335
Length: 48

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

Area-Local Opaque-LSA (Area 0.0.0.1)

LS age: 503
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x20f3
Length: 28

MPLS TE router ID : 10.0.1.2

Number of Links : 0

LS age: 503
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.34 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 34
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6073
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

```
Number of Links : 1

LS age: 734
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xa62e
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 429
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0xb912
Length: 116
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0xc0 (A|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
```

```

Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 503
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.31 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10015
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xea3e
Length: 52

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.44
SID: 24321

P2#show ip ospf database opaque-area 7.0.0.0

      OSPF Router with ID (10.0.1.2) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 781
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x7bdd
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

LS age: 453
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0x7cd3
Length: 92

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0

```

```

Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 398
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x92d7
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 2269
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33

```

```

Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 2177
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

```

Area-Local Opaque-LSA (Area 0.0.0.1)

```

LS age: 453
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0xb912
Length: 116

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0xc0 (A|N|-|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)

```

```

Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 457
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 520
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

P2#show ip ospf segment-routing capability

OSPF process 1:
-----
Advertisement Router Capability :10.0.1.1
Algorithm                      :0
SRMS Preference                :0

```

```

Total SID'S Supported      :8000
SID Range List Count      :1
SID's Range               :16000 - 23999
-----
Advertisement Router Capability :10.0.1.2
Algorithm                 :0
SRMS Preference           :0
Total SID'S Supported      :8000
SID Range List Count      :1
SID's Range               :16000 - 23999
-----
Advertisement Router Capability :10.0.1.11
Algorithm                 :0
SRMS Preference           :0
Total SID'S Supported      :8000
SID Range List Count      :1
SID's Range               :16000 - 23999
-----
Advertisement Router Capability :10.0.1.33
Algorithm                 :0
SRMS Preference           :0
Total SID'S Supported      :8000
SID Range List Count      :1
SID's Range               :16000 - 23999
-----
Advertisement Router Capability :10.0.1.44
Algorithm                 :0
SRMS Preference           :0
Total SID'S Supported      :8000
SID Range List Count      :1
SID's Range               :16000 - 23999
-----

P2#show ip ospf segment-routing announce-list
-----
Area 0.0.0.0
Instance 0
-----
Prefix:10.0.1.2/32
Origin Adv-Router:10.0.1.2
Route-Type:1
-----
Prefix:10.0.1.44/32
Origin Adv-Router:10.0.1.44
Route-Type:3
-----
Prefix:10.0.1.33/32
Origin Adv-Router:10.0.1.33
Route-Type:3
-----
Area 0.0.0.1
Instance 0
-----
Prefix:10.0.1.1/32
Origin Adv-Router:10.0.1.1
Route-Type:3
-----
Prefix:10.0.1.2/32
Origin Adv-Router:10.0.1.2
Route-Type:3
-----
Prefix:10.0.1.11/32
Origin Adv-Router:10.0.1.11
Route-Type:3
-----
Prefix:10.0.1.33/32
Origin Adv-Router:10.0.1.2

```


Route-Type:3

P3 in Area 1**Validation on P3 Router in Area 1**

P3#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: Disabled

Code	FEC	ELC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf				Nexthop		Algo-Num	UpTime	
O>	10.0.1.1/32		3	21	-	-	-	-
	-		-	20	0	0	00:29:03	-
No	10.44.2.2		-	-		Yes	17000	xe13
O>	10.0.1.2/32		1	18	-	-	-	-
	-		-	17	0	0	00:31:51	-
No	10.44.2.2		-	-		Yes	18000	xe13
O>	10.0.1.11/32		4	24	-	-	-	-
	-		0	00:29:03		-	-	-
No	10.44.2.2		-	-		Yes	16000	xe13
O>	10.0.1.33/32		2	9	-	-	-	-
	-		0	00:40:12		-	-	-
No	10.33.44.1		-	-		Yes	19000	xe15

P3#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 17000
 Nexthop addr: 10.44.2.2 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 2, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 18000
 Nexthop addr: 10.44.2.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 3, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 16000
 Nexthop addr: 10.44.2.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 4, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A

```

Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 8, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 19000
Nexthop addr: 10.33.44.1          cross connect ix: 5, op code: Push

```

P3#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			
O>	10.0.1.2/32	3	18000	18000	N/A	xe13 10.44
.2.2		LSP_DEFAULT				
O>	10.0.1.1/32	2	17000	17000	N/A	xe13 10.44
.2.2		LSP_DEFAULT				
O>	10.0.1.11/32	4	16000	16000	N/A	xe13 10.44
.2.2		LSP_DEFAULT				
O>	10.0.1.44/32	1	20000	NoLabel	N/A	N/A 127.
0.0.1		LSP_DEFAULT				
O>	10.0.1.33/32	6	19000	19000	N/A	xe15 10.33
.44.1		LSP_DEFAULT				
O>	10.44.2.2/32	5	24320	3	N/A	xe13 10.44
.2.2		LSP_DEFAULT				
O>	10.33.44.1/32	7	24321	3	N/A	xe15 10.33
.44.1		LSP_DEFAULT				

P3#show ip ospf database opaque-area self-originate

OSPF Router with ID (10.0.1.44) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.1)

```

LS age: 514
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
Checksum: 0xc6f7
Length: 28

```

MPLS TE router ID : 10.0.1.44

Number of Links : 0

```

LS age: 583
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108

```

Link connected to Broadcast network

```

Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s

```

```

Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 514
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x79ef
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.2
Interface Address : 10.33.44.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 575
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 575
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)

```

```

Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

LS age: 575
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x61e4
Length: 48

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 514
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5476
Length: 52

Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.33
SID: 24321

P3#show ip ospf database opaque-area

      OSPF Router with ID (10.0.1.44) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.1)

LS age: 607
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x20f3
Length: 28

MPLS TE router ID : 10.0.1.2

Number of Links : 0

LS age: 538
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA

```

```

Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9e38
Length: 28

```

```

MPLS TE router ID : 10.0.1.33

```

```

Number of Links : 0

```

```

LS age: 537
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
Checksum: 0xc6f7
Length: 28

```

```

MPLS TE router ID : 10.0.1.44

```

```

Number of Links : 0

```

```

LS age: 606
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108

```

```

Link connected to Broadcast network

```

```

Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

```

Number of Links : 1

```

```

LS age: 607
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.34 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 34
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6073
Length: 108

```

```

Link connected to Broadcast network

```

```

Link ID : 10.44.2.2
Interface Address : 10.44.2.2
Admin Metric : 1

```

```

Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 538
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9dd7
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.2
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 537
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x79ef
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.2
Interface Address : 10.33.44.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 838
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4

```

```
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xa62e
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 535
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 599
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 533
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0xb912
Length: 116

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
```

```

AF: 0
Flags: 0xc0 (A|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 535
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 599
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)

```



```
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

LS age: 599
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x61e4
Length: 48

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 607
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.31 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10015
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xea3e
Length: 52

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.44
SID: 24321

LS age: 535
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x4bc5
Length: 48

Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 537
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
```

```
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5476
Length: 52

Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.33
SID: 24321

P3#show mpls in-segment-table
Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 3
  Cross connect ix: 2, in intf: - in label: 18000 out-segment ix: 3
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 18000
  Nexthop addr: 10.44.2.2          cross connect ix: 2, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.1/32, ILM-ID: 2
  Cross connect ix: 1, in intf: - in label: 17000 out-segment ix: 1
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 17000
  Nexthop addr: 10.44.2.2          cross connect ix: 1, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 4
  Cross connect ix: 3, in intf: - in label: 16000 out-segment ix: 5
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 16000
  Nexthop addr: 10.44.2.2          cross connect ix: 3, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.44/32, ILM-ID: 1
  Cross connect ix: 3, in intf: - in label: 20000 out-segment ix: 0
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
  Nexthop addr: 127.0.0.1          cross connect ix: 3, op code: Pop

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 6
  Cross connect ix: 5, in intf: - in label: 19000 out-segment ix: 8
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 8, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 19000
  Nexthop addr: 10.33.44.1          cross connect ix: 5, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.44.2.2/32, ILM-ID: 5
  Cross connect ix: 4, in intf: - in label: 24320 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: xe13, out label: 3
  Nexthop addr: 10.44.2.2          cross connect ix: 4, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.33.44.1/32, ILM-ID: 7
  Cross connect ix: 6, in intf: - in label: 24321 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: xe15, out label: 3
  Nexthop addr: 10.33.44.1          cross connect ix: 6, op code: Swap

P3#show mpls out-segment-table
  Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 16000
  Nexthop addr: 10.44.2.2          cross connect ix: 3, op code: Push
```

Out-segment with ix: 8, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 19000
 Nexthop addr: 10.33.44.1 cross connect ix: 5, op code: Push

Out-segment with ix: 10, owner: N/A, Stale: NO, out intf: xe15, out label: 3
 Nexthop addr: 10.33.44.1 cross connect ix: 6, op code: Push

Out-segment with ix: 7, owner: N/A, Stale: NO, out intf: xe13, out label: 3
 Nexthop addr: 10.44.2.2 cross connect ix: 4, op code: Push

Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 18000
 Nexthop addr: 10.44.2.2 cross connect ix: 2, op code: Push

Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe13, out label: 17000
 Nexthop addr: 10.44.2.2 cross connect ix: 1, op code: Push

P3#show ip ospf database opaque-area 7.0.0.0

OSPF Router with ID (10.0.1.44) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.1)

LS age: 554
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
 Opaque Type: 7
 Opaque ID: 0
 Advertising Router: 10.0.1.2
 LS Seq Number: 80000003
 Checksum: 0xb912
 Length: 116

Prefix type : Extended Prefix TLV
 Route Type: 3
 Prefix Length: 32
 AF: 0
 Flags: 0x40 (-|N|-|-|-|-|-)
 Address Prefix: 10.0.1.1
 Flags: 0x40 (-|NP|-|-|-|-|-)
 MT-ID: 0
 Algorithm: 0
 SID: 1000

Prefix type : Extended Prefix TLV
 Route Type: 3
 Prefix Length: 32
 AF: 0
 Flags: 0xc0 (A|N|-|-|-|-|-)
 Address Prefix: 10.0.1.2
 Flags: 0x40 (-|NP|-|-|-|-|-)
 MT-ID: 0
 Algorithm: 0
 SID: 2000

Prefix type : Extended Prefix TLV
 Route Type: 3
 Prefix Length: 32
 AF: 0
 Flags: 0x40 (-|N|-|-|-|-|-)
 Address Prefix: 10.0.1.11
 Flags: 0x48 (-|NP|-|-|V|-|-|-)
 MT-ID: 0

```

    Algorithm: 0
    SID: 16000

    Prefix type : Extended Prefix TLV
    Route Type: 3
    Prefix Length: 32
    AF: 0
    Flags: 0x40 (-|N|-|-|-|-|-)
    Address Prefix: 10.0.1.33
    Flags: 0x48 (-|NP|-|-|V|-|-|-)
    MT-ID: 0
    Algorithm: 0
    SID: 19000

    LS age: 556
    Options: 0x22 (-|-|DC|-|-|-|E|-)
    LS Type: Area-Local Opaque-LSA
    Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
    Opaque Type: 7
    Opaque ID: 0
    Advertising Router: 10.0.1.33
    LS Seq Number: 80000001
    Checksum: 0x1b60
    Length: 44

    Prefix type : Extended Prefix TLV
    Route Type: 1
    Prefix Length: 32
    AF: 0
    Flags: 0x40 (-|N|-|-|-|-|-)
    Address Prefix: 10.0.1.33
    Flags: 0x48 (-|NP|-|-|V|-|-|-)
    MT-ID: 0
    Algorithm: 0
    SID: 19000

    LS age: 620
    Options: 0x22 (-|-|DC|-|-|-|E|-)
    LS Type: Area-Local Opaque-LSA
    Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
    Opaque Type: 7
    Opaque ID: 0
    Advertising Router: 10.0.1.44
    LS Seq Number: 80000001
    Checksum: 0x6514
    Length: 44

    Prefix type : Extended Prefix TLV
    Route Type: 1
    Prefix Length: 32
    AF: 0
    Flags: 0x40 (-|N|-|-|-|-|-)
    Address Prefix: 10.0.1.44
    Flags: 0x48 (-|NP|-|-|V|-|-|-)
    MT-ID: 0
    Algorithm: 0
    SID: 20000

P3#show ip ospf segment-routing capability

OSPF process 1:
-----
Advertisement Router Capability :10.0.1.2
Algorithm                     :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999

```

```

-----
Advertisement Router Capability :10.0.1.33
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----

Advertisement Router Capability :10.0.1.44
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----

P3#show ip ospf segment-routing announce-list
-----
Area 0.0.0.1
Instance 0
-----
Prefix:10.0.1.44/32
Origin Adv-Router:10.0.1.44
Route-Type:1
-----

P3#show ip ospf database

        OSPF Router with ID (10.0.1.44) (Process ID 1 VRF default)

        Router Link States (Area 0.0.0.1)

Link ID        ADV Router      Age      Seq#           CkSum  Link count
10.0.1.2       10.0.1.2       739      0x80000004    0x5e42  1
10.0.1.33      10.0.1.33      665      0x80000004    0x8e5a  2
10.0.1.44      10.0.1.44      669      0x80000006    0x42fe  3

        Net Link States (Area 0.0.0.1)

Link ID        ADV Router      Age      Seq#           CkSum
10.33.44.2     10.0.1.44      669      0x80000001    0x6ddb
10.44.2.2      10.0.1.2       739      0x80000001    0xaa07

        Summary Link States (Area 0.0.0.1)

Link ID        ADV Router      Age      Seq#           CkSum      Route
10.0.1.1       10.0.1.2       970      0x80000001    0x9889    10.0.1.1/32
10.0.1.2       10.0.1.2       970      0x80000001    0x849d    10.0.1.2/32
10.0.1.11      10.0.1.2       970      0x80000001    0x3ed8    10.0.1.11/32
10.1.1.0       10.0.1.2       970      0x80000001    0x7aab    10.1.1.0/30
10.11.1.0      10.0.1.2       970      0x80000001    0x0c0f    10.11.1.0/30

        Area-Local Opaque-LSA (Area 0.0.0.1)

Link ID        ADV Router      Age      Seq#           CkSum  Opaque ID
1.0.0.1        10.0.1.2       737      0x80000002    0x20f3    1
1.0.0.1        10.0.1.33      668      0x80000001    0x9e38    1
1.0.0.1        10.0.1.44      667      0x80000003    0xc6f7    1
1.0.0.32       10.0.1.44      736      0x80000001    0x5953    32
1.0.0.34       10.0.1.2       737      0x80000001    0x6073    34
1.0.0.36       10.0.1.33      668      0x80000001    0x9dd7    36
1.0.0.36       10.0.1.44      667      0x80000001    0x79ef    36
4.0.0.0        10.0.1.2       968      0x80000001    0xa62e    0
4.0.0.0        10.0.1.33      665      0x80000001    0xebc9    0
4.0.0.0        10.0.1.44      729      0x80000001    0xa901    0
7.0.0.0        10.0.1.2       663      0x80000003    0xb912    0
7.0.0.0        10.0.1.33      665      0x80000001    0x1b60    0
7.0.0.0        10.0.1.44      729      0x80000001    0x6514    0

```

8.0.39.30	10.0.1.44	729	0x80000001	0x61e4	10014
8.0.39.31	10.0.1.2	737	0x80000001	0xea3e	10015
8.0.39.32	10.0.1.33	665	0x80000001	0x4bc5	10016
8.0.39.32	10.0.1.44	667	0x80000001	0x5476	10016

PE2 in Area 1

Validation on PE2 Router in Area 1

```
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, SR: Disabled
```

Code	FEC	Nexthop	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC		Algo-Num	UpTime				
O>	10.0.1.1/32	-	3	16	-	-	-	-
	-	-	0	00:29:15				
	10.33.44.2	-	15	0	Yes	17000	xe15	N
O>	10.0.1.2/32	-	2	13	-	-	-	-
	-	-	0	00:32:03				
	10.33.44.2	-	12	0	Yes	18000	xe15	No
O>	10.0.1.11/32	-	4	19	-	-	-	-
	-	-	0	00:29:15				
	10.33.44.2	-	18	0	Yes	16000	xe15	No
O>	10.0.1.44/32	-	1	2	-	-	-	-
	-	-	0	00:40:22				
	10.33.44.2	-	1	0	Yes	20000	xe15	No

```
PE2#show mpls ftn-table
```

```
Primary FTN entry with FEC: 10.0.1.1/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 17000
Nexthop addr: 10.33.44.2 cross connect ix: 2, op code: Push
```

```
Primary FTN entry with FEC: 10.0.1.2/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 18000
Nexthop addr: 10.33.44.2 cross connect ix: 3, op code: Push
```

```
Primary FTN entry with FEC: 10.0.1.11/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
```

```
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 7
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 16000
Nexthop addr: 10.33.44.2 cross connect ix: 4, op code: Push
```

Primary FTN entry with FEC: 10.0.1.44/32, id: 1, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
 Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 20000
 Nexthop addr: 10.33.44.2 cross connect ix: 1, op code: Push

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				
O>	10.0.1.33/32	1	19000	Nolabel	N/A	N/A	127.0
.0.1		LSP_DEFAULT					
O>	10.0.1.1/32	3	17000	17000	N/A	xe15	10.33
.44.2		LSP_DEFAULT					
O>	10.0.1.11/32	5	16000	16000	N/A	xe15	10.33
.44.2		LSP_DEFAULT					
O>	10.0.1.2/32	4	18000	18000	N/A	xe15	10.33
.44.2		LSP_DEFAULT					
O>	10.0.1.44/32	2	20000	20000	N/A	xe15	10.33
.44.2		LSP_DEFAULT					
O>	10.33.44.2/32	6	24320	3	N/A	xe15	10.33
.44.2		LSP_DEFAULT					

PE2#show mpls in-segment-table

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.33/32, ILM-ID: 1
 Cross connect ix: 1, in intf: - in label: 19000 out-segment ix: 0
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 0, owner: CLI, Stale: NO, out intf: N/A, out label: N/A
 Nexthop addr: 127.0.0.1 cross connect ix: 1, op code: Pop

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.1/32, ILM-ID: 3
 Cross connect ix: 2, in intf: - in label: 17000 out-segment ix: 3
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 17000
 Nexthop addr: 10.33.44.2 cross connect ix: 2, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.11/32, ILM-ID: 5
 Cross connect ix: 4, in intf: - in label: 16000 out-segment ix: 7
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 16000
 Nexthop addr: 10.33.44.2 cross connect ix: 4, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.2/32, ILM-ID: 4
 Cross connect ix: 3, in intf: - in label: 18000 out-segment ix: 5
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 18000
 Nexthop addr: 10.33.44.2 cross connect ix: 3, op code: Swap

Owner: OSPF-SR, # of pops: 1, fec: 10.0.1.44/32, ILM-ID: 2
 Cross connect ix: 1, in intf: - in label: 20000 out-segment ix: 1
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 20000
 Nexthop addr: 10.33.44.2 cross connect ix: 1, op code: Swap

```

Owner: OSPF-SR, # of pops: 1, fec: 10.33.44.2/32, ILM-ID: 6
  Cross connect ix: 5, in intf: - in label: 24320 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: xe15, out label: 3
        Nexthop addr: 10.33.44.2          cross connect ix: 5, op code: Swap

PE2#show mpls out-segment-table
  Out-segment with ix: 3, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 17000
    Nexthop addr: 10.33.44.2          cross connect ix: 2, op code: Push

  Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 16000
    Nexthop addr: 10.33.44.2          cross connect ix: 4, op code: Push

  Out-segment with ix: 9, owner: N/A, Stale: NO, out intf: xe15, out label: 3
    Nexthop addr: 10.33.44.2          cross connect ix: 5, op code: Push

  Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 20000
    Nexthop addr: 10.33.44.2          cross connect ix: 1, op code: Push

  Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe15, out label: 18000
    Nexthop addr: 10.33.44.2          cross connect ix: 3, op code: Push

PE2#show ip ospf database opaque-area self-originate

    OSPF Router with ID (10.0.1.33) (Process ID 1 VRF default)

        Area-Local Opaque-LSA (Area 0.0.0.1)

LS age: 617
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9e38
Length: 28

MPLS TE router ID : 10.0.1.33

Number of Links : 0

LS age: 617
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9dd7
Length: 108

Link connected to Broadcast network
  Link ID : 10.33.44.2
  Interface Address : 10.33.44.1
  Admin Metric : 1
  Maximum bandwidth : 10000000.00 Kbits/s
  Maximum reservable bandwidth : 10000000.00 Kbits/s
  Unreserved Bandwidth :
  Number of Priority : 8
  Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s

```



```

Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 614
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

LS age: 614
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 614
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x4bc5
Length: 48

Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

PE2#show ip ospf database opaque-area

OSPF Router with ID (10.0.1.33) (Process ID 1 VRF default)

```

```
Area-Local Opaque-LSA (Area 0.0.0.1)

LS age: 694
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x20f3
Length: 28

MPLS TE router ID : 10.0.1.2

Number of Links : 0

LS age: 623
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9e38
Length: 28

MPLS TE router ID : 10.0.1.33

Number of Links : 0

LS age: 624
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000003
Checksum: 0xc6f7
Length: 28

MPLS TE router ID : 10.0.1.44

Number of Links : 0

LS age: 693
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
```

```

Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 694
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.34 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 34
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6073
Length: 108

Link connected to Broadcast network
Link ID : 10.44.2.2
Interface Address : 10.44.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 623
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9dd7
Length: 108

Link connected to Broadcast network
Link ID : 10.33.44.2
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 624
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x79ef
Length: 108

```

```
Link connected to Broadcast network
Link ID : 10.33.44.2
Interface Address : 10.33.44.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

```
Number of Links : 1
```

```
LS age: 925
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xa62e
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 620
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0xebc9
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 685
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0xa901
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 620
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
```

```

Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0xb912
Length: 116

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0xc0 (A|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 620
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)

```

```
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 685
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

LS age: 685
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x61e4
Length: 48

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 694
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.31 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10015
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xea3e
Length: 52

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.44
SID: 24321

LS age: 620
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
```

```

Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x4bc5
Length: 48

```

```

Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24320

```

```

LS age: 624
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5476
Length: 52

```

```

Link Type: 2
Link ID: 10.33.44.2
Link Data: 10.33.44.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.33
SID: 24321

```

```
PE2#show ip ospf database opaque-area 7.0.0.0
```

```
OSPF Router with ID (10.0.1.33) (Process ID 1 VRF default)
```

```
Area-Local Opaque-LSA (Area 0.0.0.1)
```

```

LS age: 640
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0xb912
Length: 116

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

```

```

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0

```

```

Flags: 0xc0 (A|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 640
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x1b60
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 19000

LS age: 705
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x6514
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.44

```



```

Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 20000

PE2#show ip ospf segment-routing capability

OSPF process 1:
-----
Advertisement Router Capability :10.0.1.2
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count          :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :10.0.1.33
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count          :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :10.0.1.44
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count          :1
SID's Range                    :16000 - 23999
-----

PE2#show ip ospf segment-routing announce-list
-----
Area 0.0.0.1
Instance 0
-----
Prefix:10.0.1.33/32
Origin Adv-Router:10.0.1.33
Route-Type:1
-----

PE2#show ip ospf database

OSPF Router with ID (10.0.1.33) (Process ID 1 VRF default)

Router Link States (Area 0.0.0.1)

Link ID      ADV Router    Age      Seq#          CkSum  Link count
10.0.1.2     10.0.1.2      740      0x80000004   0x5e42  1
10.0.1.33    10.0.1.33     664      0x80000004   0x8e5a  2
10.0.1.44    10.0.1.44     670      0x80000006   0x42fe  3

Net Link States (Area 0.0.0.1)

Link ID      ADV Router    Age      Seq#          CkSum
10.33.44.2   10.0.1.44     670      0x80000001   0x6ddb
10.44.2.2    10.0.1.2      740      0x80000001   0xaa07

Summary Link States (Area 0.0.0.1)

Link ID      ADV Router    Age      Seq#          CkSum      Route
10.0.1.1     10.0.1.2      971      0x80000001   0x9889  10.0.1.1/32
10.0.1.2     10.0.1.2      971      0x80000001   0x849d  10.0.1.2/32
10.0.1.11    10.0.1.2      971      0x80000001   0x3ed8  10.0.1.11/32
10.1.1.0     10.0.1.2      971      0x80000001   0x7aab  10.1.1.0/30
10.11.1.0    10.0.1.2      971      0x80000001   0x0c0f  10.11.1.0/30

Area-Local Opaque-LSA (Area 0.0.0.1)

```

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	10.0.1.2	738	0x80000002	0x20f3	1
1.0.0.1	10.0.1.33	667	0x80000001	0x9e38	1
1.0.0.1	10.0.1.44	668	0x80000003	0xc6f7	1
1.0.0.32	10.0.1.44	737	0x80000001	0x5953	32
1.0.0.34	10.0.1.2	738	0x80000001	0x6073	34
1.0.0.36	10.0.1.33	667	0x80000001	0x9dd7	36
1.0.0.36	10.0.1.44	668	0x80000001	0x79ef	36
4.0.0.0	10.0.1.2	969	0x80000001	0xa62e	0
4.0.0.0	10.0.1.33	664	0x80000001	0xebc9	0
4.0.0.0	10.0.1.44	729	0x80000001	0xa901	0
7.0.0.0	10.0.1.2	664	0x80000003	0xb912	0
7.0.0.0	10.0.1.33	664	0x80000001	0x1b60	0
7.0.0.0	10.0.1.44	729	0x80000001	0x6514	0
8.0.39.30	10.0.1.44	729	0x80000001	0x61e4	10014
8.0.39.31	10.0.1.2	738	0x80000001	0xea3e	10015
8.0.39.32	10.0.1.33	664	0x80000001	0x4bc5	10016
8.0.39.32	10.0.1.44	668	0x80000001	0x5476	10016

Configuring OSPF SR Mapping Server with LDP

This section shows how to configure OSPF segment routing mapping server to work with LDP.

A segment routing mapping server allocates Segment Identifiers (SIDs) for prefixes and ranges of prefixes in an OSPF segment routing domain.

LDP can advertise SIDs for destinations in the LDP part of the network that does not support segment routing. These segments are converted to MPLS labels and installed in the FTN/ILM and forwarding tables.

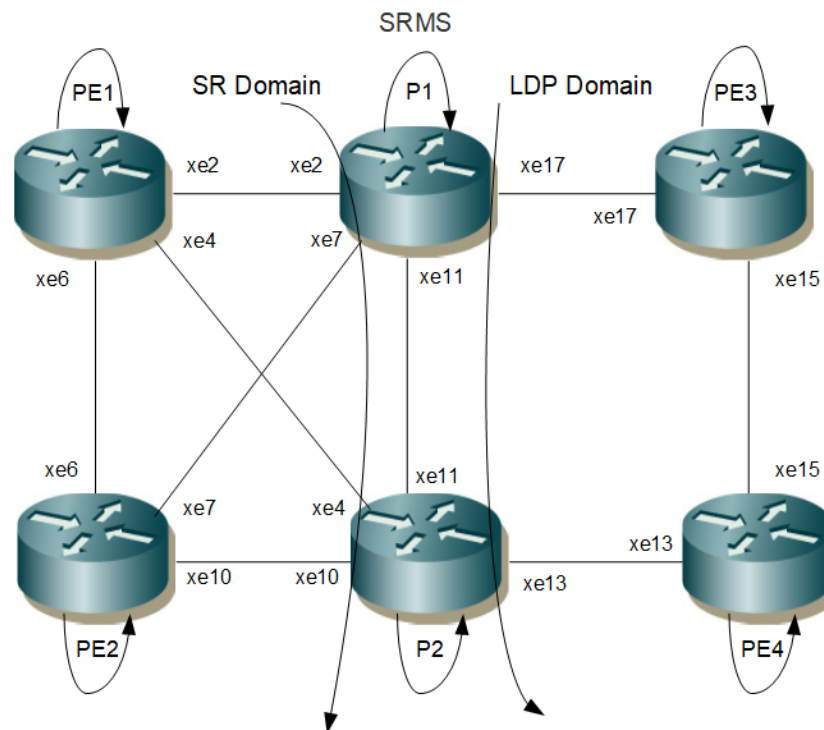
OSPF uses OSPF TLVs to advertise any additional attributes associated with a prefix by adding new TLVs or sub-TLVs to the existing OSPF TLVs.



Note: Configure PE1 and PE2 router as a OSPF Segment routing, P1 and P2 router as a segment routing mapping server and PE3 and PE4 as a OSPF with LDP.

Topology

Figure 19. ISIS Segment routing with mapping server and LDP



- PE1 and PE2 are in a OSPF segment routing domain.
- P1 and P2 configured as mapping servers.
- PE3 and PE4 are in OSPF with LDP domain.

Configuraion

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 10.0.1.11/32 secondary	Configure the IP address of the interface
PE1(config-if)#prefix-sid index 500 no-php	Configure prefix SID absolute value.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface xe2	Enter interface mode.
PE1(config-if)#ip address 10.11.1.1/30	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface xe4	Enter interface mode.
PE1(config-if)#ip address 10.11.2.1/30	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface xe6	Enter interface mode.
PE1(config-if)#ip address 10.11.22.1/30	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router ospf 1	Enter OSPF router mode for process ID 1.
PE1(config-router)#router-id 10.0.1.11	Set the router id.
PE1(config-router)# network 10.0.1.11/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0..
PE1(config-router)# network 10.11.1.0/30 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
PE1(config-router)# network 10.11.2.0/30 area 0.0.0.0	Advertise the xe4 interface in OSPF area 0.
PE1(config-router)# network 10.11.22.0/30 area 0.0.0.0	Advertise the xe6 interface in OSPF area 0.
PE1(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range (16000-23999)
PE1(config-router)#segment-routing mpls	Enable segment routing under router process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 10.0.1.22/32 secondary	Configure the IP address of the interface.
PE2(config-if)#prefix-sid index 1000 no-php	Configure prefix SID absolute value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface xe6	Enter interface mode.
PE2(config-if)#ip address 10.11.22.2/30	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface xe7	Enter interface mode.
PE2(config-if)#ip address 10.22.1.1/30	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface xe10	Enter interface mode.
PE2(config-if)#ip address 10.22.2.1/30	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router ospf 1	Enter OSPF router mode for process ID 1.
PE2(config-router)# router-id 10.0.1.22	Advertise the router-id.
PE2(config-router)# network 10.0.1.22/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0
PE2(config-router)#network 10.11.22.0/30 area 0.0.0.0	Advertise the xe6 interface in OSPF area 0
PE2(config-router)# network 10.22.1.0/30 area 0.0.0.0	Advertise the xe7 interface in OSPF area 0
PE2(config-router)# network 10.22.2.0/30 area 0.0.0.0	Advertise the xe10 interface in OSPF area 0
PE2(config-router)# ospf segment-routing global block 16000 23999	Advertise segment routing global block range(16000-23999).
PE2(config-router)#segment-routing mpls	Enable segment routing under router process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration.

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 10.0.1.1/32 secondary	Configure the IP address of the interface.
P1(config-if)#prefix-sid index 2000 no-php	Configure prefix SID absolute value.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface xe2	Enter interface mode.
P1(config-if)#ip address 10.11.1.2/30	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface xe7	Enter interface mode.
P1(config-if)#ip address 10.22.1.2/30	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface xel1	Enter interface mode.
P1(config-if)#ip address 10.1.1.1/30	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface xe17	Enter interface mode.
P1(config-if)#ip address 10.33.1.2/30	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#enable-ldp ipv4	
P1(config-if)#exit	Exit interface mode.
P1(config)#router ospf 1	Set the routing process ID
P1(config-router)# router-id 10.0.1.1	Advertise the router-id
P1(config-router)# network 10.0.1.1/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0
P1(config-router)# network 10.1.1.0/30 area 0.0.0.0	Advertise the xe12 interface in OSPF area 0
P1(config-router)# network 10.11.1.0/30 area 0.0.0.0	Advertise the xe2 interface in OSPF area 0
P1(config-router)# network 10.22.1.0/30 area 0.0.0.0	Advertise the xe7 interface in OSPF area 0
P1(config-router)# network 10.33.1.0/30 area 0.0.0.0	Advertise the xe17 interface in OSPF area 0
P1(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range (16000-23999).
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)#segment-routing prefix-sid-map advertise-local	Enable segment routing prefix-sid-map advertise-local under router process.

P1(config-router)#exit	Exit router mode.
P1(config)#segment-routing	Enter segment routing configuration mode
P1(config-sr)# mapping-server	Enter mapping server mode.
P1(config-sr-ms)#srms preference 200	Configure segment routing mapping server preference value.
P1(config-sr-ms)#prefix-sid-map address-family ipv4	Enter prefix-SID mapping configuration mode.
P1(config-sr-ms-map-af4)# 10.0.1.33/32 4000 range 1	Configure mapping server entry for assigning s-ids to prefixes.
P1(config-sr-ms-map-af4)# 10.0.1.44/32 5000 range 1	Configure mapping server entry for assigning s-ids to prefixes.
P1(config-sr-ms-map-af4)#end	Exit to privileged mode.
P1#configure terminal	Enter configure mode.
P1(config)#router ldp	Enter router ldp mode.
P1(config-router)#exit	Exit router mode.
P1#configure terminal	Enter configure mode.
P1(config)# mpls lsp-stitching	Enable mpls lsp stitching on global mode.
P1(config-router)#exit	Exit router mode.
P1(config)#commit	Commit the candidate configuration to the running configuration.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#router ldp	Enter router ldp mode.
P2(config-router)#exit	Exit router mode.
P2#configure terminal	Enter configure mode.
P2(config)# mpls lsp-stitching	Enable mpls lsp stitching on global mode.
P2(config-router)#exit	Exit router mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 10.0.1.2/32 secondary	Configure the IP address of the interface.
P2(config-if)# prefix-sid index 3000 no-php	Configure Prefix SID value.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xe4	Enter interface mode.
P2(config-if)#ip address 10.11.2.2/30	Configure the IP address of the interface.

P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xe10	Enter interface mode.
P2(config-if)#ip address 10.22.2.2/30	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
R4(config-if)#exit	Exit interface mode.
P2(config)#interface xe11	Enter interface mode.
P2(config-if)#ip address 10.1.1.2/30	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xe13	Enter interface mode.
P2(config-if)#ip address 10.44.2.2/30	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)# enable-ldp ipv4	Enable ldp ipv4 under interface.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ospf 1	Set the routing process ID .
P2(config-router)# router-id 10.0.1.2	Advertise the router-id.
P2(config-router)# network 10.0.1.2/32 area 0.0.0.0	Advertise the xe17 interface in OSPF area 0.
P2(config-router)# network 10.1.1.0/30 area 0.0.0.0	Advertise the xe11 interface in OSPF area 0.
P2(config-router)# network 10.11.2.0/30 area 0.0.0.0	Advertise the xe4 interface in OSPF area 0.
P2(config-router)# network 10.22.2.0/30 area 0.0.0.0	Advertise the xe10 interface in OSPF area 0.
P2(config-router)# network 10.44.2.0/30 area 0.0.0.0	Advertise the xe13 interface in OSPF area 0.
P2(config-router)# ospf segment-routing global block 16000 23999	Advertise the segment routing global block range (16000-23999).
P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)# segment-routing prefix-sid-map advertise-local	Enable segment routing prefix-sid-map advertise-local under router process.
P2(config-router)#exit	Exit router mode.
P2(config)#segment-routing	Enter segment routing configuration mode
P2(config-sr)# mapping-server	Enter mapping server mode.
P2(config-sr-ms)#srms preference 100	Configure segment routing mapping server preference value.
P2(config-sr-ms)#prefix-sid-map address-family ipv4	Enter prefix-SID mapping configuration mode.
P2(config-sr-ms-map-af4)# 10.0.1.33/32 1111	Configure mapping server entry for assigning s-ids to

range 1	prefixes.
P2(config-sr-ms-map-af4)# 10.0.1.44/32 2222 range 1	Configure mapping server entry for assigning s-ids to prefixes.
P2(config-sr-ms-map-af4)#end	Exit to privileged mode.
P2#configure terminal	Enter configure mode
P2(config)#router ldp	Enter router ldp mode.
P2(config-router)#exit	Exit router mode.
P2#configure terminal	Enter configure mode.
P2(config)# mpls lsp-stitching	Enable mpls lsp stitching on global mode.
P2(config-router)#exit	Exit router mode
P2(config)#commit	Commit the candidate configuration to the running configuration.

PE3

The following are the step-by-step configurations on the PE3 router.

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter interface mode.
PE3(config-if)#ip address 10.0.1.33/32 secondary	Configure the IP address of the interface.
PE3(config-if)#exit	Exit interface mode.
PE3(config)#router ldp	Enter router ldp mode.
PE3(config-router)#exit	Exit router mode.
PE3(config)#interface xe15	Enter interface mode.
PE3(config-if)#ip address 10.33.44.1/30	Configure the IP address of the interface.
PE3(config-if)#label-switching	Enable label switching.
PE3(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface.
PE3(config-if)#exit	Exit interface mode.
PE3(config)#interface xe17	Enter interface mode.
PE3(config-if)#ip address 10.33.1.1/30	Configure the IP address of the interface.
PE3(config-if)#label-switching	Enable label switching.
PE3(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface.
PE3(config-if)#exit	Exit interface mode.
PE3(config)#router ospf 1	Set the routing process ID
PE3(config-router)#router-id 10.0.1.33	Advertise the router-id
PE3(config-router)#network 10.0.1.33/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.

PE3(config-router)#network 10.33.1.0/30 area 0.0.0.0	Advertise the xe10 interface in OSPF area 0.
PE3(config-router)# network 10.33.44.0/30 area 0.0.0.0	Advertise the xe15 interface in OSPF area 0.
PE3(config-router)#exit	Exit router mode.
PE3(config)#commit	Commit the candidate configuration to the running configuration.

PE4

The following are the step-by-step configurations on the PE4 router.

PE4#configure terminal	Enter configure mode.
PE4(config)#interface lo	Enter interface mode.
PE4(config-if)#ip address 10.0.1.44/32 secondary	Configure the IP address of the interface.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#router ldp	Enter router ldp mode.
PE4(config-if)#exit	Exit interface mode.
PE4(config)#interface xe13	Enter interface mode.
PE4(config-if)#ip address 10.44.2.1/30	Configure the IP address of the interface.
PE4(config-if)#label-switching	Enable label switching.
PE4(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface
PE4(config-if)#exit	Exit interface mode.
PE4(config)#interface xe15	Enter interface mode.
PE4(config-if)#ip address 10.33.44.2/30	Configure the IP address of the interface.
PE4(config-if)#label-switching	Enable label switching.
PE4(config-if)#enable-ldp ipv4	Enable LDP ipv4 in interface
PE4(config-if)#exit	Exit interface mode.
PE4(config)#router ospf 1	Set the routing process ID
PE4(config-router)#router-id 10.0.1.44	Advertise the router-id
PE4(config-router)#network 10.0.1.44/32 area 0.0.0.0	Advertise the lo interface in OSPF area 0.
PE4(config-router)#network 10.33.44.0/30 area 0.0.0.0	Advertise the xe15 interface in OSPF area 0.
PE4(config-router)# network 10.44.2.0/30 area 0.0.0.0	Advertise the xe13 interface in OSPF area 0.
PE4(config-router)#exit	Exit router mode.
PE4(config)#commit	Commit the candidate configuration to the running configuration.

Validation 1

PE1

Verify OSPF neighbor adjacency between routers.

```
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
10.0.1.1	1	Full/Backup	00:00:33	10.11.1.2	xe2	0
10.0.1.2	1	Full/Backup	00:00:29	10.11.2.2	xe4	0
10.0.1.22	1	Full/Backup	00:00:35	10.11.22.2	xe6	0

```
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
10.0.1.11	1	Full/DR	00:00:31	10.11.22.1	xe6	0
10.0.1.1	1	Full/Backup	00:00:37	10.22.1.2	xe7	0
10.0.1.2	1	Full/Backup	00:00:32	10.22.2.2	xe10	0

```
P1#show ip ospf neighbor
```

```
Total number of full neighbors: 4
```

```
OSPF process 1 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.0.1.2	1	Full/Backup	00:00:33	10.1.1.2	xe11	0
10.0.1.11	1	Full/DR	00:00:31	10.11.1.1	xe2	0
10.0.1.22	1	Full/DR	00:00:40	10.22.1.1	xe7	0
10.0.1.33	1	Full/Backup	00:00:35	10.33.1.1	xe17	0

```
P2#show ip ospf neighbor
```

```
Total number of full neighbors: 4
```

```
OSPF process 1 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance ID
10.0.1.1	1	Full/DR	00:00:34	10.1.1.1	xe11	0
10.0.1.11	1	Full/DR	00:00:32	10.11.2.1	xe4	0
10.0.1.22	1	Full/DR	00:00:35	10.22.2.1	xe10	0
10.0.1.44	1	Full/Backup	00:00:38	10.44.2.1	xe13	0

```
PE3#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
10.0.1.1	1	Full/DR	00:00:30	10.33.1.2	xe17	0
10.0.1.44	1	Full/DR	00:00:36	10.33.44.2	xe15	0

```
PE4#show ip ospf neighbor
```

```
Total number of full neighbors: 2
```

```
OSPF process 1 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance
10.0.1.33	1	Full/Backup	00:00:40	10.33.44.1	xe15	0
10.0.1.2	1	Full/DR	00:00:32	10.44.2.2	xe13	0

Validation 2

Verify that segment routing is enabled and that prefix SIDs are announced to other routers.

Verify that prefix SIDs are installed as labels in the MPLS forwarding table. Verify the same in FTN and ILM tables.

PE1 and PE2 Segment Routing Domain

Validation on PE1 and PE2 Segment Routing Domain

```
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, SR: Disabled
```

Code	FEC	Nexthop	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC		Algo-Num	UpTime				
O>	10.0.1.1/32	-	2	13	-	-	-	-
	-	-	-	0	-	01:04:07	-	-
	10.11.1.2	-	-	12	0	Yes	18000	xe6 No
O>	10.0.1.2/32	-	3	20	-	-	-	-
	-	-	-	19	0	01:00:59	-	-
	10.11.2.2	-	-	0	-	Yes	19000	xe5 No
O>	10.0.1.22/32	-	1	4	-	-	-	-
	-	-	-	3	0	01:07:11	-	-
	10.11.22.2	-	-	0	-	Yes	17000	xe4 No
O>	10.0.1.33/32	-	5	10	-	-	-	-
	-	-	-	9	0	00:07:54	-	-
	10.11.1.2	-	-	0	-	Yes	20000	xe6 No
O>	10.0.1.44/32	-	4	2	-	-	-	-
	-	-	-	1	0	00:43:30	-	-
	10.11.2.2	-	-	0	-	Yes	21000	xe5 No

```
PE1#
```

```
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, UPStr - upstream
```

```
ILM-ECMP LDP: Disabled, SR: Disabled
```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop		pri	Algo-Num	UpTime	
UPStr peers						
O>	10.0.1.2/32	5	19000	19000	N/A	xe5
10.11.2.2	Yes	0	01:02:37			
O>	10.0.1.22/32	3	17000	17000	N/A	xe4
10.11.22.2	Yes	0	01:08:49			
O>	10.0.1.11/32	1	16500	Nolabel	N/A	N/A
127.0.0.1	Yes	0	01:11:29			
O>	10.0.1.1/32	4	18000	18000	N/A	xe6
10.11.1.2	Yes	0	01:05:45			
O>	10.11.22.2/32	2	24320	3	N/A	xe4
10.11.22.2	Yes	0	01:08:49			
O>	10.0.1.44/32	7	21000	21000	N/A	xe5
10.11.2.2	Yes	0	00:45:08			

```

O> 10.0.1.33/32          9      20000      20000      N/A      xe6
10.11.1.2                Yes 0      00:09:32
O> 10.11.2.2/32          6      24321      3          N/A      xe5
10.11.2.2                Yes 0      01:02:34
O> 10.11.1.2/32          8      24322      3          N/A      xe6
10.11.1.2                Yes 0      00:42:52
PE1#

PE1#show mpls ftn-table
Primary FTN entry with FEC: 10.0.1.1/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 4
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 18000
Nexthop addr: 10.11.1.2      cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe4, out label: 19000
Nexthop addr: 10.11.2.2      cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.22/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe6, out label: 17000
Nexthop addr: 10.11.22.2     cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 10
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 20000
Nexthop addr: 10.11.1.2      cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 5, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 12
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 12, owner: OSPF-SR, Stale: NO, out intf: xe4, out label: 21000
Nexthop addr: 10.11.2.2      cross connect ix: 8, op code: Push

```

P1 and P2 Segment Routing Mapping Server Domain

Validation on P1 and P2 Segment Routing Mapping Server Domain

```

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, SR: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
O>	10.0.1.1/32	2	9	-		-	-
	-	-	-	0	01:07:42	-	-
24	No	10.22.1.2	8	-	0	Yes	18000 xe
O>	10.0.1.2/32	-	17	-	-	-	-
	-	-	-	0	01:04:34	-	-
19	No	10.22.2.2	16	-	0	Yes	19000 ge
O>	10.0.1.11/32	1	2	-	-	-	-
	-	-	-	0	01:10:37	-	-
25	No	10.11.22.1	1	-	0	Yes	16500 xe
O>	10.0.1.33/32	5	15	-	-	-	-
	-	-	-	0	00:11:29	-	-
24	No	10.22.1.2	14	-	0	Yes	20000 xe
O>	10.0.1.44/32	4	12	-	-	-	-
	-	-	-	0	00:47:05	-	-
19	No	10.22.2.2	11	-	0	Yes	21000 ge

PE2#PE2#

PE2#show mpls ilm-table t

% VRF t not configured

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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled

ILM-ECMP LDP: Disabled, SR: Disabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop	pri	Algo-Num	UpTime	UPStr	peers
O>	10.0.1.1/32	5	18000	18000	N/A	xe24 10.22.
1.2	Yes 0	01:07:51				
O>	10.0.1.22/32	1	17000	Nolabel	N/A	N/A 127.0.
0.1	Yes 0	01:11:05				
O>	10.0.1.11/32	2	16500	16500	N/A	xe25 10.11.
22.1	Yes 0	01:10:46				
O>	10.11.22.1/32	3	24320	3	N/A	xe25 10.11.
22.1	Yes 0	01:10:46				
O>	10.0.1.33/32	9	20000	20000	N/A	xe24 10.22.
1.2	Yes 0	00:11:38				
O>	10.0.1.2/32	6	19000	19000	N/A	ge19 10.22.
2.2	Yes 0	01:04:43				
O>	10.0.1.44/32	8	21000	21000	N/A	ge19 10.22.
2.2	Yes 0	00:47:14				
O>	10.22.1.2/32	4	24321	3	N/A	xe24 10.22.
1.2	Yes 0	01:07:55				
O>	10.22.2.2/32	7	24322	3	N/A	ge19 10.22.
2.2	Yes 0	01:04:38				

PE2#

PE2#

PE2#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.1/32, id: 2, row status: Active

Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

```

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 6
Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 6, owner: OSPF-SR, Stale: NO, out intf: xe7, out label: 18000
Nexthop addr: 10.22.1.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 8
Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 8, owner: OSPF-SR, Stale: NO, out intf: xe10, out label: 19000
Nexthop addr: 10.22.2.2 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe6, out label: 16000
Nexthop addr: 10.11.22.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 4, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 11
Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 11, owner: OSPF-SR, Stale: NO, out intf: xe7, out label: 20000
Nexthop addr: 10.22.1.2 cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 5, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 13
Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 13, owner: OSPF-SR, Stale: NO, out intf: xe10, out label: 21000
Nexthop addr: 10.22.2.2 cross connect ix: 9, op code: Push
Pl#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: Disabled
Code FEC Nexthop FTN-ID Nhlfe-ID Tunnel-ID Pri Out-Label Out-
Intf ELC Nexthop Algo-Num UpTime
O> 10.0.1.2/32 3 14 - - 01:09:32 -
- - - 13 0 Yes 19000 cd40/3
No 10.1.1.2 - - - 0
O> 10.0.1.11/32 1 19 - - 01:12:38 -
- - - 18 0 Yes 16500 cd40/2
No 10.11.1.1 - - - 0
O> 10.0.1.22/32 2 5 - - 01:12:38 -
- - - 4 0 Yes 17000 cd40/1
No 10.22.1.1 - - - 0
L> 10.0.1.33/32 5 16 - -

```

```

- - - 2 N/A 00:16:06
- - - 24 - 10.33.1.1 - -
L> 10.0.1.44/32 7 - - N/A 00:13:10
- - - 23 - 10.33.1.1 - -
O 10.0.1.44/32 4 9 0 Yes 21000 cd40/3
No 10.1.1.2 0 - - - -
L> 10.33.44.0/30 6 16 - - -
- - - 2 N/A 00:16:06
- - - 2 No 10.33.1.1 - -
P1#
P1#

P1#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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-
Intf/VRF Nexthop pri Algo-Num UpTime
UPStr peers
s
O> 10.0.1.33/32 10 20000 3 N/A ce4
10.33.1.1 Yes 0 00:16:19
O> 10.0.1.1/32 1 18000 Nolabel N/A N/A
127.0.0.1 Yes 0 01:12:58
O> 10.0.1.22/32 3 17000 17000 N/A cd40/1
10.22.1.1 Yes 0 01:12:51
O> 10.0.1.11/32 2 16500 16500 N/A cd40/2
10.11.1.1 Yes 0 01:12:51
O> 10.0.1.2/32 6 19000 19000 N/A cd40/3
10.1.1.2 Yes 0 01:09:45
L> 10.11.2.0/30 15 24325 Nolabel N/A N/A
127.0.0.1 Yes N/A 00:16:23 1
s
L> 10.0.1.2/32 11 24320 1 9000 N/A cd40/3
10.1.1.2 Yes N/A 00:16:23
1
O> 10.0.1.44/32 7 21000 21000 N/A cd40/3
10.1.1.2 Yes 0 00:52:15
s
L> 10.0.1.22/32 13 24322 17000 N/A cd40/1
10.22.1.1 Yes N/A 00:16:23 1
s
L> 10.0.1.11/32 12 24321 1 6500 N/A cd40/2
10.11.1.1 Yes N/A 00:16:23 1
O> 10.22.1.1/32 4 25600 3 N/A cd40/1
10.22.1.1 Yes 0 01:12:51
L> 10.22.2.0/30 17 24327 Nolabel N/A N/A
127.0.0.1 Yes N/A 00:16:23 1
L> 10.11.22.0/30 16 24326 Nolabel N/A N/A
127.0.0.1 Yes N/A 00:16:23 1
L> 10.44.2.0/30 18 24329 Nolabel N/A N/A
127.0.0.1 Yes N/A 00:16:23 1
O> 10.11.1.1/32 8 25602 3 N/A cd40/2
10.11.1.1 Yes 0 00:50:00
O> 10.1.1.2/32 5 25601 3 N/A cd40/3
10.1.1.2 Yes 0 01:09:48
O> 10.33.1.1/32 9 25603 3 N/A ce4
10.33.1.1 Yes 0 00:16:43
P1#

```



```
P1#show mpls ftn-table
Primary FTN entry with FEC: 10.0.1.2/32, id: 3, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 19000
Nexthop addr: 10.1.1.2 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 1, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe2, out label: 16000
Nexthop addr: 10.11.1.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.22/32, id: 2, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 4, in intf: - in label: 0 out-segment ix: 6
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 6, owner: OSPF-SR, Stale: NO, out intf: xe7, out label: 17000
Nexthop addr: 10.22.1.1 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, 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: 7, 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: xe17, out label: 3
Nexthop addr: 10.33.1.1 cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 7, 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: 9, 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: xe17, out label: 25601
Nexthop addr: 10.33.1.1 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 6, row status: Active
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 11
Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 11, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 21000
Nexthop addr: 10.1.1.2 cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.33.44.0/30, 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: 7, 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: xe17, out label: 3
Nexthop addr: 10.33.1.1 cross connect ix: 7, op code: Push
```

P2#

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, (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: Disabled

Code	FEC	Nexthop	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC			Algo-Num	UpTime			
O>	10.0.1.1/32	-	1	2	-	-	-	-
	No	10.1.1.1	-	1	0	0	18000	01:09:30 xe6
O>	10.0.1.11/32	-	2	19	-	-	0	01:09:30
	No	10.11.2.1	-	18	0	Yes	16500	xe2
O>	10.0.1.22/32	-	3	22	-	-	-	-
	No	10.22.2.1	-	21	0	Yes	17000	xe19
L>	10.0.1.33/32	-	7	27	-	-	-	-
	No	10.1.1.1	0	N/A	00:13:10	-	-	-
	Yes	24331	xe9	26	-	No	10.44.2.1	-
O	10.0.1.33/32	6	7	7	0	Yes	20000	xe6
L>	10.0.1.44/32	-	4	6	-	-	-	-
	No	10.1.1.1	0	N/A	00:51:47	-	-	-
	Yes	3	xe9	4	-	No	10.44.2.1	-
L>	10.33.44.0/30	-	5	17	-	-	-	-
	No	10.1.1.1	0	N/A	00:13:15	-	-	-
	Yes	24332	xe9	16	-	No	10.44.2.1	-

P2#

P2#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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop	pri	Algo-Num	UpTime		
UPStr peers						
s						
O>	10.0.1.44/32	9	21000	3	N/A	xe9 10.44.2.
1	Yes 0	00:52:00				
O>	10.0.1.1/32	2	18000	18000	N/A	xe6 10.1.
1.1	Yes 0	01:09:43				
O>	10.0.1.11/32	3	16500	16500	N/A	xe2 10.11
.2.1	Yes 0	01:09:43				
O>	10.0.1.22/32	4	17000	17000	N/A	xe19 10.22
.2.1	Yes 0	01:09:43				
O>	10.0.1.2/32	1	19000	Nolabel	N/A	N/A 127.0
.0.1	Yes 0	01:09:50				
O>	10.0.1.33/32	17	20000	20000	N/A	xe6 10.1.
1.1	Yes 0	00:16:40				
L>	10.33.1.0/30	15	24326	Nolabel	N/A	N/A 127.0
.0.1	Yes N/A	00:52:04	1			
L>	10.11.22.0/30	13	24324	Nolabel	N/A	N/A 127.0
.0.1	Yes N/A	00:52:04	1			
s						
L>	10.0.1.11/32	11	24321	16500	N/A	xe2 10.11.2.
1	Yes N/A	00:52:04	1			

```

s
L> 10.0.1.1/32      10      24320      18000      N/A      xe6      10.1.1.1
    Yes N/A      00:52:04  1

s
L> 10.0.1.22/32     12      24322      17000      N/A      xe19     10.22.2.
1    Yes N/A      00:52:04  1
  L> 10.22.1.0/30    14      24325      Nolabel    N/A      N/A      127.0
  .0.1 Yes N/A      00:52:04  1
  O> 10.1.1.1/32     5      25600      3          N/A      xe6      10.1.
1.1  Yes 0        01:09:43
  L> 10.11.1.0/30    16      24328      Nolabel    N/A      N/A      127.0
  .0.1 Yes N/A      00:50:46  1
  O> 10.22.2.1/32    7      25602      3          N/A      xe19     10.22
.2.1 Yes 0        01:09:39
  O> 10.11.2.1/32    6      25601      3          N/A      xe2      10.11
.2.1 Yes 0        01:09:41
  O> 10.44.2.1/32    8      25603      3          N/A      xe9      10.44
.2.1 Yes 0        00:52:18
P2#
P2#

```

P2#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.1/32, id: 1, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 18000
 Nexthop addr: 10.1.1.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, id: 2, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 9
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe4, out label: 16000
 Nexthop addr: 10.11.2.1 cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 10.0.1.22/32, id: 3, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 8
 Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 8, owner: OSPF-SR, Stale: NO, out intf: xe10, out label: 17000
 Nexthop addr: 10.22.2.1 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 7, 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: 9, 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: xe13, out label: 25600
 Nexthop addr: 10.44.2.1 cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 6, row status: Active
 Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none

Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A
 Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 11
 Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
 Out-segment with ix: 11, owner: OSPF-SR, Stale: NO, out intf: xe11, out label: 20000

```

Nexthop addr: 10.1.1.1      cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, 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: 7, 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: xe13, out label: 3
  Nexthop addr: 10.44.2.1      cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.33.44.0/30, 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: 7, 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: xe13, out label: 3
  Nexthop addr: 10.44.2.1      cross connect ix: 7, op code: Push

```

PE3 and PE4 LDP Domain

Validation on PE3 and PE4 LDP Domain

```

PE3#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, SR: Disabled
Code   FEC           Nexthop   FTN-ID   Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC             Intf      Algo-Num UpTime
L>     10.0.1.1/32  -         1         -         2         -     -         -
      -         -         -         -         -         -     -         -
      Yes       3         -         ce21      1         No      10.33.1.2  -     -
L>     10.0.1.2/32  -         2         -         4         -     -         -
      -         -         -         -         -         -     -         -
      Yes      24320      -         ce21      3         No      10.33.1.2  -     -
      Yes      24321      -         cd24/3    28        No      10.33.44.2  -     -
L>     10.0.1.11/32 -         3         -         6         -     -         -
      -         -         -         -         -         -     -         -
      Yes      24321      -         ce21      5         No      10.33.1.2  -     -
L>     10.0.1.22/32 -         4         -         8         -     -         -
      -         -         -         -         -         -     -         -
      Yes      24322      -         ce21      7         No      10.33.1.2  -     -
L>     10.0.1.44/32 -         5         -         30        No      10.33.1.2  -     -
      -         -         -         -         -         -     -         -
      Yes       3         -         cd24/3    29        No      10.33.44.2  -     -
L>     10.1.1.0/30  -         6         -         2         -     -         -
      -         -         -         -         -         -     -         -
      Yes       3         -         ce21      1         No      10.33.1.2  -     -
L>     10.11.1.0/30 -         7         -         2         -     -         -
      -         -         -         -         -         -     -         -
      Yes       3         -         ce21      1         No      10.33.1.2  -     -
L>     10.11.2.0/30 -         8         -         12        No      10.33.1.2  -     -
      -         -         -         -         -         -     -         -

```

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                Yes      24325      ce21      11      No      -      10.33.1.2      -      -
                Yes      24325      cd24/3     32      No      -      10.33.44.2      -      -
L> 10.11.22.0/30      9      -      14      N/A      00:16:08
                Yes      24326      ce21      13      No      -      10.33.1.2      -      -
L> 10.22.1.0/30      10      -      2      N/A      00:16:08
                Yes      3      ce21      1      No      -      10.33.1.2      -      -
L> 10.22.2.0/30      11      -      16      N/A      00:16:08
                Yes      24327      ce21      15      No      -      10.33.1.2      -      -
                Yes      24328      cd24/3     33      No      -      10.33.44.2      -      -
L> 10.44.2.0/30      12      -      30      N/A      00:13:09
                Yes      3      cd24/3     29      No      -      10.33.44.2      -      -
PE3#PE3#
PE3#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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code  FEC/VRF/L2CKT      ILM-ID      In-Label      Out-Label      In-Intf      Out-
Intf/VRF      Nexthop      pri  Algo-Num  UpTime
UPStr peers
L> 10.11.2.0/30      8      24327      24325      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.0.1.22/32      4      24323      24322      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.0.1.2/32      2      24321      24320      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.0.1.1/32      1      24320      3      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.0.1.11/32      3      24322      24321      N/A      c e21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.1.1.0/30      6      24325      3      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.0.1.44/32      5      24324      3      N/A      cd24/3
    10.33.44.2      Yes  N/A      00:13:23  2
L> 10.11.1.0/30      7      24326      3      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.22.1.0/30      10     24329      3      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.11.22.0/30      9      24328      24326      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.22.2.0/30      11     24330      24327      N/A      ce21
    10.33.1.2      Yes  N/A      00:13:23  1
L> 10.44.2.0/30      12     24331      3      N/A      cd24/3
    10.33.44.2      Yes  N/A      00:13:23  2
PE3#
PE3#

PE3# show mpls ftn-table
Primary FTN entry with FEC: 10.0.1.1/32, 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: xe17, out label: 3

```

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Nexthop addr: 10.33.1.2          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, 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: 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: xe17, out label: 25600
  Nexthop addr: 10.33.1.2          cross connect ix: 2, op code: Push

  Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 3
  Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
  Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe15, out label: 25601
  Nexthop addr: 10.33.44.2        cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, 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: 5
  Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 5, owner: LDP, Stale: NO, out intf: xe17, out label: 25601
  Nexthop addr: 10.33.1.2          cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.22/32, 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: 6, 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: xe17, out label: 25602
  Nexthop addr: 10.33.1.2          cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 10.0.1.44/32, id: 6, 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: 4
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 4, owner: N/A, Stale: NO, out intf: xe15, out label: 3
  Nexthop addr: 10.33.44.2        cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.1.1.0/30, id: 7, 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: xe17, out label: 3
  Nexthop addr: 10.33.1.2          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.11.1.0/30, id: 8, 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: xe17, out label: 3
  Nexthop addr: 10.33.1.2          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.11.2.0/30, id: 9, 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: 9
  Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 9, owner: LDP, Stale: NO, out intf: xe17, out label: 25604
```

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Nexthop addr: 10.33.1.2      cross connect ix: 8, op code: Push

Cross connect ix: 8, 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: xe15, out label: 25607
Nexthop addr: 10.33.44.2      cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.11.22.0/30, id: 10, 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: 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: xe17, out label: 25605
Nexthop addr: 10.33.1.2      cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.22.1.0/30, id: 11, 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: xe17, out label: 3
Nexthop addr: 10.33.1.2      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.22.2.0/30, id: 12, 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: 10, 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: xe17, out label: 25606
Nexthop addr: 10.33.1.2      cross connect ix: 10, op code: Push

Cross connect ix: 10, 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: xe15, out label: 25610
Nexthop addr: 10.33.44.2      cross connect ix: 10, op code: Push

Primary FTN entry with FEC: 10.44.2.0/30, id: 13, 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: 4
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 4, owner: N/A, Stale: NO, out intf: xe15, out label: 3
Nexthop addr: 10.33.44.2      cross connect ix: 7, op code: Push

```

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, SR: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
L>	10.0.1.1/32	1	2	-	-	-	-
	-	-	-	N/A	00:54:02	-	-
	Yes	24320	xe45	No	10.44.2.2	-	-
	Yes	24320	xe44	No	10.33.44.1	-	-
L>	10.0.1.2/32	2	4	-	-	-	-
	-	-	N/A	00:54:02	-	-	-
	Yes	3	xe45	No	10.44.2.2	-	-

```

L> 10.0.1.11/32      3      6      -      -      N/A      00:54:02      -      -
      -      -      -      5      -
      Yes      24321      xe45      No      10.44.2.2      -      -
L> 10.0.1.22/32      4      8      -      -      -      -      -
      -      -      N/A      00:54:02
      7
      Yes      24322      xe45      No      10.44.2.2      -      -
L> 10.0.1.33/32      10      27      -      -      -      -      -
      -      -      N/A      00:15:23
      26
      Yes      3      x e44      No      10.33.44.1      -      -
L> 10.1.1.0/30      5      4      -      -      -      -      -
      -      -      N/A      00:54:02
      3
      Yes      3      xe45      No      10.44.2.2      -      -
L> 10.11.1.0/30      11      16      -      -      -      N/A      00:52:46
      -      -      15
      Yes      24328      xe45      No      10.44.2.2      -      -
      29
      Yes      2      4326      xe44      No      10.33.44.1      -      -
L> 10.11.2.0/30      6      4      -      -      -      -      -
      -      -      N/A      00:54:02
      3
      Yes      3      xe45      No      10.44.2.2      -      -
L> 10.11.22.0/30      7      10      -      -      -      -      -
      -      -      N/A      00:54:02
      9
      Yes      24324      xe45      No      10.44.2.2      -      -
L> 10.22.1.0/30      8      12      -      -      -      -      -
      -      -      N/A      00:54:02
      11
      Yes      24325      xe45      No      10.44.2.2      -      -
      3      0
      Yes      24329      xe44      No      10.33.44.1      -      -
L> 10.22.2.0/30      9      4      -      -      -      -      -
      -      -      N/A      00:54:02
      3
      Yes      3      xe45      No      10.44.2.2      -      -
L> 10.33.1.0/30      12      7      -      -      -      -      -
      -      -      N/A      00:15:23
      26
      Yes      3      xe44      No      10.33.44.1      -      -
PE4#

PE4# 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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code  FEC/VRF/L2CKT  ILM-ID  In-Label  Out-Label  In-Intf  Out-
Intf/VRF  Nexthop  pri  Algo-Num  UpTime  UPStr  peers
L> 10.33.1.0/30      3      24329      3      N/A      xe44      10
.33.44.1      Yes  N/A      00:15:29  1
L> 10.1.1.0/30      7      24324      3      N/A      xe45      10
.44.2.2      Yes  N/A      00:15:29  1
L> 10.0.1.11/32      5      24322      24321      N/A      xe45      10
.44.2.2      Yes  N/A      00:15:29  1
L> 10.0.1.2/32      4      24321      3      N/A      xe45      10
.44.2.2      Yes  N/A      00:15:29  1
L> 10.0.1.22/32      6      24323      24322      N/A      xe45      10
.44.2.2      Yes  N/A      00:15:29  1
L> 10.11.22.0/30      9      24326      24324      N/A      xe45      10
.44.2.2      Yes  N/A      00:15:29  1
L> 10.11.2.0/30      8      24325      3      N/A      xe45      10

```



```
.44.2.2      Yes  N/A      00:15:29  1
L> 10.22.2.0/30      10      24328      3      N/A      xe45      10
.44.2.2      Yes  N/A      00:15:29  1
L> 10.0.1.33/32      2      24331      3      N/A      xe44      10
.33.44.1      Yes  N/A      00:15:29  1
L> 10.33.44.0/30      1      24332      Nolabel    N/A      N/A      12
7.0.0.1      Yes  N/A      00:15:35  1
PE4#
```

PE4#show mpls ftn-table

Primary FTN entry with FEC: 10.0.1.1/32, 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: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 1, owner: LDP, Stale: NO, out intf: xe13, out label: 25600
 Nexthop addr: 10.44.2.2 cross connect ix: 1, op code: Push

Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 10
 Owner: LDP, Persistent: No, Admin Status: Down, Oper Status: Not present
 Out-segment with ix: 10, owner: LDP, Stale: NO, out intf: xe15, out label: 25600
 Nexthop addr: 10.33.44.1 cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, 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: 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: xe13, out label: 3
 Nexthop addr: 10.44.2.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.0.1.11/32, 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: 3
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 3, owner: LDP, Stale: NO, out intf: xe13, out label: 25601
 Nexthop addr: 10.44.2.2 cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 10.0.1.22/32, 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: 4
 Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 4, owner: LDP, Stale: NO, out intf: xe13, out label: 25602
 Nexthop addr: 10.44.2.2 cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, 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: 11
 Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
 Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe15, out label: 3
 Nexthop addr: 10.33.44.1 cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.1.1.0/30, id: 6, 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: 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: xe13, out label: 3
 Nexthop addr: 10.44.2.2 cross connect ix: 2, op code: Push

```

Primary FTN entry with FEC: 10.11.1.0/30, id: 7, 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: 6
    Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 6, owner: LDP, Stale: NO, out intf: xe13, out label: 25604
  Nexthop addr: 10.44.2.2      cross connect ix: 6, op code: Push

  Cross connect ix: 6, 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: xe15, out label: 25606
  Nexthop addr: 10.33.44.1      cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 10.11.2.0/30, id: 8, 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: 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: xe13, out label: 3
  Nexthop addr: 10.44.2.2      cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.11.22.0/30, id: 9, 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: 7
    Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 7, owner: LDP, Stale: NO, out intf: xe13, out label: 25605
  Nexthop addr: 10.44.2.2      cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.22.1.0/30, id: 10, 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: 8
    Owner: LDP, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 8, owner: LDP, Stale: NO, out intf: xe13, out label: 25606
  Nexthop addr: 10.44.2.2      cross connect ix: 8, op code: Push

  Cross connect ix: 8, 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: xe15, out label: 25609
  Nexthop addr: 10.33.44.1      cross connect ix: 8, op code: Push

Primary FTN entry with FEC: 10.22.2.0/30, id: 11, 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: 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: xe13, out label: 3
  Nexthop addr: 10.44.2.2      cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 10.33.1.0/30, id: 12, 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: 11
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 11, owner: N/A, Stale: NO, out intf: xe15, out label: 3
  Nexthop addr: 10.33.44.1      cross connect ix: 5, op code: Push

```

In the forwarding tables above, the configured prefix SIDs are in the Out-Label column which is expected and is global

across the topology. The swap happens in between nodes with this prefix SID and there is no local labelling

Validation 3

P1

Show the routes details and OSPF database.

```
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"
C       10.0.1.1/32 is directly connected, lo, 13:13:51
O       10.0.1.2/32 [110/2] via 10.1.1.2, xe11, 00:21:59
O       10.0.1.11/32 [110/2] via 10.11.1.1, xe2, 00:23:13
O       10.0.1.22/32 [110/2] via 10.22.1.1, xe7, 00:23:11
O       10.0.1.33/32 [110/2] via 10.33.1.1, xe17, 00:15:45
O       10.0.1.44/32 [110/3] via 10.1.1.2, xe11, 00:12:45
        [110/3] via 10.33.1.1, xe17
C       10.1.1.0/30 is directly connected, xe11, 13:14:18
C       10.11.1.0/30 is directly connected, xe2, 13:15:21
O       10.11.2.0/30 [110/2] via 10.1.1.2, xe11, 00:23:13
        [110/2] via 10.11.1.1, xe2
O       10.11.22.0/30 [110/2] via 10.22.1.1, xe7, 00:23:13
        [110/2] via 10.11.1.1, xe2
C       10.22.1.0/30 is directly connected, xe7, 13:06:03
O       10.22.2.0/30 [110/2] via 10.22.1.1, xe7, 00:23:11
        [110/2] via 10.1.1.2, xe11
C       10.33.1.0/30 is directly connected, xe17, 12:42:33
O       10.33.44.0/30 [110/2] via 10.33.1.1, xe17, 00:15:45
O       10.44.2.0/30 [110/2] via 10.1.1.2, xe11, 00:21:59
C       127.0.0.0/8 is directly connected, lo, 13:29:28

Gateway of last resort is not set

P1#show ip route ospf
IP Route Table for VRF "default"
O       10.0.1.2/32 [110/2] via 10.1.1.2, xe11, 00:23:02
O       10.0.1.11/32 [110/2] via 10.11.1.1, xe2, 00:24:16
O       10.0.1.22/32 [110/2] via 10.22.1.1, xe7, 00:24:14
O       10.0.1.33/32 [110/2] via 10.33.1.1, xe17, 00:16:48
O       10.0.1.44/32 [110/3] via 10.1.1.2, xe11, 00:13:48
        [110/3] via 10.33.1.1, xe17
O       10.11.2.0/30 [110/2] via 10.1.1.2, xe11, 00:24:16
        [110/2] via 10.11.1.1, xe2
O       10.11.22.0/30 [110/2] via 10.22.1.1, xe7, 00:24:16
        [110/2] via 10.11.1.1, xe2
O       10.22.2.0/30 [110/2] via 10.22.1.1, xe7, 00:24:14
        [110/2] via 10.1.1.2, xe11
O       10.33.44.0/30 [110/2] via 10.33.1.1, xe17, 00:16:48
O       10.44.2.0/30 [110/2] via 10.1.1.2, xe11, 00:23:02

Gateway of last resort is not set

P1# show ip ospf database

        OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)
```

Router Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Link count
10.0.1.1	10.0.1.1	1062	0x8000000b	0x9642	5
10.0.1.2	10.0.1.2	883	0x8000000b	0x4b6d	5
10.0.1.11	10.0.1.11	1404	0x8000000a	0x0bf4	4
10.0.1.22	10.0.1.22	1419	0x80000009	0xefc2	4
10.0.1.33	10.0.1.33	507	0x80000007	0x3347	3
10.0.1.44	10.0.1.44	512	0x80000007	0x3709	3

Net Link States (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum
10.1.1.1	10.0.1.1	1435	0x80000001	0x7397
10.11.1.1	10.0.1.11	1514	0x80000001	0x15d8
10.11.2.1	10.0.1.11	1404	0x80000001	0x18d3
10.11.22.1	10.0.1.11	1612	0x80000001	0x546f
10.22.1.1	10.0.1.22	1506	0x80000001	0xbc10
10.22.2.1	10.0.1.22	1419	0x80000001	0xbf0b
10.33.1.2	10.0.1.1	1062	0x80000001	0x9b2f
10.33.44.2	10.0.1.44	512	0x80000001	0x6ddb
10.44.2.2	10.0.1.2	883	0x80000001	0xaa07

Area-Local Opaque-LSA (Area 0.0.0.0)

Link ID	ADV Router	Age	Seq#	CkSum	Opaque ID
1.0.0.1	10.0.1.1	1503	0x80000003	0x1afa	1
1.0.0.1	10.0.1.2	1417	0x80000003	0x1ef4	1
1.0.0.1	10.0.1.11	1512	0x80000004	0x40bf	1
1.0.0.1	10.0.1.22	1505	0x80000003	0x6e7c	1
1.0.0.1	10.0.1.33	509	0x80000005	0x963c	1
1.0.0.1	10.0.1.44	510	0x80000005	0xc2f9	1
1.0.0.12	10.0.1.1	199	0x80000002	0xc26c	12
1.0.0.12	10.0.1.11	367	0x80000002	0x68bd	12
1.0.0.16	10.0.1.2	1402	0x80000001	0xc860	16
1.0.0.16	10.0.1.11	1402	0x80000001	0x74ac	16
1.0.0.20	10.0.1.11	1610	0x80000001	0x38bc	20
1.0.0.20	10.0.1.22	1611	0x80000001	0x14d4	20
1.0.0.22	10.0.1.1	209	0x80000002	0x709e	22
1.0.0.22	10.0.1.22	1505	0x80000001	0xd526	22
1.0.0.28	10.0.1.2	1417	0x80000001	0x62a4	28
1.0.0.28	10.0.1.22	1417	0x80000001	0xcb28	28
1.0.0.30	10.0.1.1	1433	0x80000001	0x1023	30
1.0.0.30	10.0.1.2	1434	0x80000001	0x2809	30
1.0.0.32	10.0.1.44	882	0x80000001	0x5953	32
1.0.0.34	10.0.1.2	881	0x80000001	0x6073	34
1.0.0.36	10.0.1.33	509	0x80000001	0x9dd7	36
1.0.0.36	10.0.1.44	510	0x80000001	0x79ef	36
1.0.0.40	10.0.1.33	1061	0x80000001	0x07c0	40
1.0.0.42	10.0.1.1	1060	0x80000001	0xd113	42
4.0.0.0	10.0.1.1	689	0x80000002	0x29c7	0
4.0.0.0	10.0.1.2	664	0x80000002	0xfa59	0
4.0.0.0	10.0.1.11	56	0x80000002	0x6e5c	0
4.0.0.0	10.0.1.22	315	0x80000002	0x2c93	0
7.0.0.0	10.0.1.1	1541	0x80000001	0x6ffe	0
7.0.0.0	10.0.1.2	1459	0x80000001	0x6917	0
7.0.0.0	10.0.1.11	1747	0x80000001	0x94d6	0
7.0.0.0	10.0.1.22	55	0x80000002	0x240b	0
7.0.0.1	10.0.1.1	689	0x80000001	0x4587	1
7.0.0.2	10.0.1.1	689	0x80000001	0xa331	2
8.0.39.20	10.0.1.1	1511	0x80000001	0xd567	10004
8.0.39.20	10.0.1.11	1512	0x80000001	0x0713	10004
8.0.39.22	10.0.1.2	1402	0x80000001	0x4d6b	10006
8.0.39.22	10.0.1.11	1402	0x80000001	0x50c3	10006
8.0.39.24	10.0.1.11	1610	0x80000001	0xae29	10008
8.0.39.24	10.0.1.22	1611	0x80000001	0xa752	10008
8.0.39.25	10.0.1.1	1503	0x80000001	0xf52b	10009

8.0.39.25	10.0.1.22	1505	0x80000001	0xc72c	10009
8.0.39.28	10.0.1.2	1417	0x80000001	0x2974	10012
8.0.39.28	10.0.1.22	25	0x80000002	0x05e6	10012
8.0.39.29	10.0.1.1	89	0x80000002	0x0d1f	10013
8.0.39.29	10.0.1.2	1434	0x80000001	0x9534	10013
8.0.39.31	10.0.1.2	881	0x80000001	0x2df9	10015
8.0.39.35	10.0.1.1	1060	0x80000001	0x3d87	10019

Validation 4

P1

Show the details of routers configured with segment routing.

```
P1#show ip ospf segment-routing capability

OSPF process 1:
-----
Advertisement Router Capability :10.0.1.1
Algorithm                      :0
SRMS Preference                :200
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :10.0.1.2
Algorithm                      :0
SRMS Preference                :100
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :10.0.1.11
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :10.0.1.22
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----

P1#show ip ospf database opaque-area self-originate

      OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 1738
Options: 0x22 (-|-|DC|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0x1afa
```

Length: 28

MPLS TE router ID : 10.0.1.1

Number of Links : 0

LS age: 433

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)

Opaque Type: 1

Opaque ID: 12

Advertising Router: 10.0.1.1

LS Seq Number: 80000002

Checksum: 0xc26c

Length: 108

Link connected to Broadcast network

Link ID : 10.11.1.1

Interface Address : 10.11.1.2

Admin Metric : 1

Maximum bandwidth : 10000000.00 Kbits/s

Maximum reservable bandwidth : 10000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s

Priority 1 : 10000000.00 Kbits/s

Priority 2 : 10000000.00 Kbits/s

Priority 3 : 10000000.00 Kbits/s

Priority 4 : 10000000.00 Kbits/s

Priority 5 : 10000000.00 Kbits/s

Priority 6 : 10000000.00 Kbits/s

Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 443

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)

Opaque Type: 1

Opaque ID: 22

Advertising Router: 10.0.1.1

LS Seq Number: 80000002

Checksum: 0x709e

Length: 108

Link connected to Broadcast network

Link ID : 10.22.1.1

Interface Address : 10.22.1.2

Admin Metric : 1

Maximum bandwidth : 10000000.00 Kbits/s

Maximum reservable bandwidth : 10000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s

Priority 1 : 10000000.00 Kbits/s

Priority 2 : 10000000.00 Kbits/s

Priority 3 : 10000000.00 Kbits/s

Priority 4 : 10000000.00 Kbits/s

Priority 5 : 10000000.00 Kbits/s

Priority 6 : 10000000.00 Kbits/s

Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 23

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)

Opaque Type: 1

Opaque ID: 30

Advertising Router: 10.0.1.1

LS Seq Number: 80000002

Checksum: 0x0e24

Length: 108

```
Link connected to Broadcast network
Link ID : 10.1.1.1
Interface Address : 10.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1294
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.42 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 42
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xd113
Length: 108

Link connected to Broadcast network
Link ID : 10.33.1.2
Interface Address : 10.33.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 924
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x29c7
Length: 52

Range Size: 8000
Base-SID: 16000
Algorithm: 0
Preference: 200

LS age: 1775
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x6ffe
```

```
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

LS age: 924
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x4587
Length: 48

Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 1
Flags: 0x00 (-|-|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 4000

LS age: 924
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.2 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 2
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xa331
Length: 48

Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 1
Flags: 0x00 (-|-|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 5000

LS age: 1746
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xd567
Length: 48
```



```
Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24960
```

```
LS age: 43
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0xf32c
Length: 48
```

```
Link Type: 2
Link ID: 10.22.1.1
Link Data: 10.22.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24961
```

```
LS age: 323
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x0d1f
Length: 52
```

```
Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
SID: 24962
```

```
LS age: 1294
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.35 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10019
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x3d87
Length: 52
```

```
Link Type: 2
Link ID: 10.33.1.2
Link Data: 10.33.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.33
SID: 24963
```

```
P1#show ip ospf database opaque-area
```

```
OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 1744
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000003
Checksum: 0x1afa
Length: 28

MPLS TE router ID : 10.0.1.1

Number of Links : 0

LS age: 1658
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.2
LS Seq Number: 80000003
Checksum: 0x1ef4
Length: 28

MPLS TE router ID : 10.0.1.2

Number of Links : 0

LS age: 8
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.11
LS Seq Number: 80000005
Checksum: 0x3ec0
Length: 28

MPLS TE router ID : 10.0.1.11

Number of Links : 0

LS age: 1747
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.22
LS Seq Number: 80000003
Checksum: 0x6e7c
Length: 28

MPLS TE router ID : 10.0.1.22

Number of Links : 0

LS age: 750
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
```

```

Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.33
LS Seq Number: 80000005
Checksum: 0x963c
Length: 28

MPLS TE router ID : 10.0.1.33

Number of Links : 0

LS age: 751
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 10.0.1.44
LS Seq Number: 80000005
Checksum: 0xc2f9
Length: 28

MPLS TE router ID : 10.0.1.44

Number of Links : 0

LS age: 440
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0xc26c
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 608
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x68bd
Length: 108

Link connected to Broadcast network
Link ID : 10.11.1.1
Interface Address : 10.11.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s

```

```

Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1643
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.16 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 16
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0xc860
Length: 108

Link connected to Broadcast network
Link ID : 10.11.2.1
Interface Address : 10.11.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1643
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.16 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 16
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x74ac
Length: 108

Link connected to Broadcast network
Link ID : 10.11.2.1
Interface Address : 10.11.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1852
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.20 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 20

```

Advertising Router: 10.0.1.11
 LS Seq Number: 80000001
 Checksum: 0x38bc
 Length: 108

Link connected to Broadcast network

Link ID : 10.11.22.1
 Interface Address : 10.11.22.1
 Admin Metric : 1
 Maximum bandwidth : 10000000.00 Kbits/s
 Maximum reservable bandwidth : 10000000.00 Kbits/s
 Unreserved Bandwidth :
 Number of Priority : 8
 Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
 Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
 Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
 Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1853
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.20 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 20
 Advertising Router: 10.0.1.22
 LS Seq Number: 80000001
 Checksum: 0x14d4
 Length: 108

Link connected to Broadcast network

Link ID : 10.11.22.1
 Interface Address : 10.11.22.2
 Admin Metric : 1
 Maximum bandwidth : 10000000.00 Kbits/s
 Maximum reservable bandwidth : 10000000.00 Kbits/s
 Unreserved Bandwidth :
 Number of Priority : 8
 Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
 Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
 Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
 Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 450
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 22
 Advertising Router: 10.0.1.1
 LS Seq Number: 80000002
 Checksum: 0x709e
 Length: 108

Link connected to Broadcast network

Link ID : 10.22.1.1
 Interface Address : 10.22.1.2
 Admin Metric : 1
 Maximum bandwidth : 10000000.00 Kbits/s
 Maximum reservable bandwidth : 10000000.00 Kbits/s
 Unreserved Bandwidth :
 Number of Priority : 8
 Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
 Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
 Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s

```

Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1747
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 22
Advertising Router: 10.0.1.22
LS Seq Number: 80000001
Checksum: 0xd526
Length: 108

Link connected to Broadcast network
Link ID : 10.22.1.1
Interface Address : 10.22.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1658
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.28 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 28
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x62a4
Length: 108

Link connected to Broadcast network
Link ID : 10.22.2.1
Interface Address : 10.22.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1658
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.28 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 28
Advertising Router: 10.0.1.22
LS Seq Number: 80000001
Checksum: 0xcb28
Length: 108

Link connected to Broadcast network

```

```

Link ID : 10.22.2.1
Interface Address : 10.22.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 30
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x0e24
Length: 108

Link connected to Broadcast network
Link ID : 10.1.1.1
Interface Address : 10.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1676
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.30 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 30
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x2809
Length: 108

Link connected to Broadcast network
Link ID : 10.1.1.1
Interface Address : 10.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1124
Options: 0x22 (-|-|DC|-|-|-|E|-)

```

```

LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 10.0.1.44
LS Seq Number: 80000001
Checksum: 0x5953
Length: 108

```

```

Link connected to Broadcast network

```

```

Link ID : 10.44.2.2
Interface Address : 10.44.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

```

Number of Links : 1

```

```

LS age: 1123
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.34 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 34
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6073
Length: 108

```

```

Link connected to Broadcast network

```

```

Link ID : 10.44.2.2
Interface Address : 10.44.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

```

Number of Links : 1

```

```

LS age: 750
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 10.0.1.33
LS Seq Number: 80000001
Checksum: 0x9dd7
Length: 108

```

```

Link connected to Broadcast network

```

```

Link ID : 10.33.44.2
Interface Address : 10.33.44.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :

```



```

    Number of Priority : 8
    Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
    Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
    Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
    Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

    Number of Links : 1

    LS age: 751
    Options: 0x22 (-|-|DC|-|-|-|E|-)
    LS Type: Area-Local Opaque-LSA
    Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
    Opaque Type: 1
    Opaque ID: 36
    Advertising Router: 10.0.1.44
    LS Seq Number: 80000001
    Checksum: 0x79ef
    Length: 108

    Link connected to Broadcast network
    Link ID : 10.33.44.2
    Interface Address : 10.33.44.2
    Admin Metric : 1
    Maximum bandwidth : 10000000.00 Kbits/s
    Maximum reservable bandwidth : 10000000.00 Kbits/s
    Unreserved Bandwidth :
    Number of Priority : 8
    Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
    Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
    Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
    Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

    Number of Links : 1

    LS age: 130
    Options: 0x22 (-|-|DC|-|-|-|E|-)
    LS Type: Area-Local Opaque-LSA
    Link State ID: 1.0.0.40 (Area-Local Opaque-Type/ID)
    Opaque Type: 1
    Opaque ID: 40
    Advertising Router: 10.0.1.33
    LS Seq Number: 80000002
    Checksum: 0x05c1
    Length: 108

    Link connected to Broadcast network
    Link ID : 10.33.1.2
    Interface Address : 10.33.1.1
    Admin Metric : 1
    Maximum bandwidth : 10000000.00 Kbits/s
    Maximum reservable bandwidth : 10000000.00 Kbits/s
    Unreserved Bandwidth :
    Number of Priority : 8
    Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
    Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
    Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
    Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

    Number of Links : 1

    LS age: 1301
    Options: 0x22 (-|-|DC|-|-|-|E|-)
    LS Type: Area-Local Opaque-LSA
    Link State ID: 1.0.0.42 (Area-Local Opaque-Type/ID)
    Opaque Type: 1
    Opaque ID: 42
    Advertising Router: 10.0.1.1
    LS Seq Number: 80000001

```

Checksum: 0xd113
Length: 108

Link connected to Broadcast network

Link ID : 10.33.1.2
Interface Address : 10.33.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 931
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x29c7
Length: 52

Range Size: 8000
Base-SID: 16000
Algorithm: 0
Preference: 200

LS age: 905
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0xfa59
Length: 52

Range Size: 8000
Base-SID: 16000
Algorithm: 0
Preference: 100

LS age: 298
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x6e5c
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0

```
LS age: 556
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.22
LS Seq Number: 80000002
Checksum: 0x2c93
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 1782
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x6ffe
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000
```

```
LS age: 1701
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6917
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 3000
```

```
LS age: 1989
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
```

```

Checksum: 0x94d6
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 296
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.22
LS Seq Number: 80000002
Checksum: 0x240b
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.22
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

LS age: 931
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 1
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x4587
Length: 48

Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 1
Flags: 0x00 (-|-|-|-|-|-|-)
Address Prefix: 10.0.1.33
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 4000

LS age: 931
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.2 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 2
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xa331
Length: 48

```

```

Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 1
Flags: 0x00 (-|-|-|-|-|-|-)
Address Prefix: 10.0.1.44
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 5000

LS age: 1753
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xd567
Length: 48

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24960

LS age: 1754
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x0713
Length: 52

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.1
SID: 24961

LS age: 1643
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x4d6b
Length: 48

Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24322

```

```
LS age: 1643
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x50c3
Length: 52
```

```
Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
SID: 24962
```

```
LS age: 1852
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.24 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10008
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0xae29
Length: 52
```

```
Link Type: 2
Link ID: 10.11.22.1
Link Data: 10.11.22.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.22
SID: 24960
```

```
LS age: 1853
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.24 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10008
Advertising Router: 10.0.1.22
LS Seq Number: 80000001
Checksum: 0xa752
Length: 48
```

```
Link Type: 2
Link ID: 10.11.22.1
Link Data: 10.11.22.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24960
```

```
LS age: 50
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 10.0.1.1
```

```
LS Seq Number: 80000002
Checksum: 0xf32c
Length: 48
```

```
Link Type: 2
Link ID: 10.22.1.1
Link Data: 10.22.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24961
```

```
LS age: 1747
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 10.0.1.22
LS Seq Number: 80000001
Checksum: 0xc72c
Length: 52
```

```
Link Type: 2
Link ID: 10.22.1.1
Link Data: 10.22.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.1
SID: 24961
```

```
LS age: 1658
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.28 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10012
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x2974
Length: 48
```

```
Link Type: 2
Link ID: 10.22.2.1
Link Data: 10.22.2.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24321
```

```
LS age: 266
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.28 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10012
Advertising Router: 10.0.1.22
LS Seq Number: 80000002
Checksum: 0x05e6
Length: 52
```

```
Link Type: 2
Link ID: 10.22.2.1
Link Data: 10.22.2.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
```

SID: 24962

LS age: 330
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x0d1f
Length: 52

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
SID: 24962

LS age: 86
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.29 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10013
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0x9335
Length: 48

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 1123
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.31 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10015
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x2df9
Length: 52

Link Type: 2
Link ID: 10.44.2.2
Link Data: 10.44.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.44
SID: 24323

LS age: 1301
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.35 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10019


```

Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x3d87
Length: 52

```

```

Link Type: 2
Link ID: 10.33.1.2
Link Data: 10.33.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.33
SID: 24963

```

```
P1#show ip ospf database opaque-area 7.0.0.0
```

```
OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)
```

```
Area-Local Opaque-LSA (Area 0.0.0.0)
```

```

LS age: 1793
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0x6ffe
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.1
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2000

```

```

LS age: 1711
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x6917
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.2
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 3000

```

```

LS age: 2000
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7

```

```

Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x94d6
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.11
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 16000

LS age: 307
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 10.0.1.22
LS Seq Number: 80000002
Checksum: 0x240b
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 10.0.1.22
Flags: 0x40 (-|NP|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1000

```

P1#show ip ospf database opaque-area 8.0.39.20

OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

```

LS age: 1777
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.1
LS Seq Number: 80000001
Checksum: 0xd567
Length: 48

```

```

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24960

```

```

LS age: 1778
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)

```

```
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x0713
Length: 52

Link Type: 2
Link ID: 10.11.1.1
Link Data: 10.11.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.1
SID: 24961

P1#show ip ospf database opaque-area 8.0.39.22

      OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 1671
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.2
LS Seq Number: 80000001
Checksum: 0x4d6b
Length: 48

Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24322

LS age: 1671
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 10.0.1.11
LS Seq Number: 80000001
Checksum: 0x50c3
Length: 52

Link Type: 2
Link ID: 10.11.2.1
Link Data: 10.11.2.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 10.0.1.2
SID: 24962

P1#show ip ospf database opaque-area 4.0.0.0

      OSPF Router with ID (10.0.1.1) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 1018
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
```

```
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.1
LS Seq Number: 80000002
Checksum: 0x29c7
Length: 52
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
Preference: 200
```

```
LS age: 990
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.2
LS Seq Number: 80000002
Checksum: 0xfa59
Length: 52
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
Preference: 100
```

```
LS age: 384
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.11
LS Seq Number: 80000002
Checksum: 0x6e5c
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

```
LS age: 642
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 10.0.1.22
LS Seq Number: 80000002
Checksum: 0x2c93
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm: 0
```

Validation 5

P2

Displays the details of mapping server entries.

```
P2#show segment-routing mapping-server prefix-sid-map ipv4
Prefix          SID Index      Range      Flags
10.0.1.33/32    6000           1
10.0.1.44/32    7000           1
```

Number of mapping entries: 2

```
P2#show ip ospf segment-routing mapping-table active
OSPF process ID: 1
Conflict Resolution Policy: Quarantine
```

```
Prefix          SID Index      Range      Flags
10.0.1.1/32     2000           1
10.0.1.2/32     3000           1
10.0.1.11/32    0              1
10.0.1.22/32    1000           1
10.0.1.33/32    4000           1
10.0.1.44/32    5000           1
```

Number of mapping entries in Active Table: 6

```
P2#show ip ospf segment-routing mapping-table inactive
OSPF process ID: 1
Conflict Resolution Policy: Quarantine
```

```
Prefix          SID Index      Range      Flags
10.0.1.33/32    6000           1
10.0.1.44/32    7000           1
```

Number of mapping entries in Inactive Table: 2

```
P2#show ip ospf segment-routing announce-list
```

```
-----
Area 0.0.0.0
```

```
Instance 0
```

```
-----
Prefix:10.0.1.2/32
Origin Adv-Router:10.0.1.2
Route-Type:1
-----
```

Configuring OSPFv6 Segment Routing IPv6

This section contains configurations of SRv6 with OSPFv6.

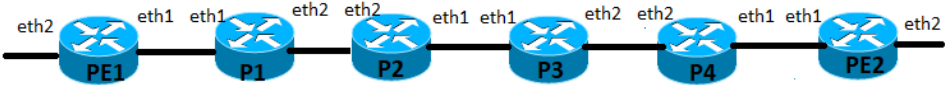
SRv6

SRv6 represents Segment routing (SR) with IPv6 data plane. The SRv6 network program is encoded in the Segment Routing extension Header (SRH) of a network packet as an ordered list of segments. The most significant bits of a segment are called “locator”. The locator acts as any routed subnet address and ensures that the packet destined for a segment is routed to the destination of that segment. The packet goes from node to node and receives sequential processing according to ordered instructions selected by the source and encoded in the SRH. No intermediate node changes the flow.

Topology

Below example shows the SRv6 with OSPFv6 configurations.

Figure 20. OSPFv6 Configuration Topology



Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1(config)#tunnel-policy policy0	Configure tunnel policy
PE1(config-tnl-policy)#color 1	Color to be used as 1
PE1(config-tnl-policy)#exit	Exit to config mode
PE1(config)#ip vrf vrf1	IP VRF config with name vrf1
PE1(config-vrf)#tunnel-select-policy policy0	Tunnel-policy to be mapped as policy0
PE1(config-vrf)#rd 1:1	Route-distinguisher value
PE1(config-vrf)#route-target both 1:1	Route target value
PE1(config-vrf)#exit	Exit to config mode
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ipv6 address	Configure IPv6 address of the loopback interface.

cafe:1:2::11/128	
PE1(config-if)# ip address 11.11.11.11/32 secondary	Configure IP address on the loopback interface as secondary
PE1(config-if)# ipv6 address cafe:1:2::11/128	Configure IPv6 address
PE1(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.
PE1(config-if)#ipv6 address 1111::2/64	Configure the IPv6 address of the interface.
PE1(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
PE1(config)#interface eth2	Enter interface mode.
PE1(config-if)#ip vrf forwarding vrf1	Attaching eth2 to as part of vrf1
PE1(config-if)#ip address 101.1.1.1/24	Configure the IP address of the interface.
PE1(config-if)#exit	Exit interface mode
PE1(config)#router ipv6 ospf 1	Set the routing process ID as 1
PE1(config-router-af)#segment-routing srv6	Enable SRv6 under IPv6 address-family
PE1(config-router-af-srv6)# srv6-locator Srs123	Name to SRv6 locator
PE1(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE1(config-router)#exit	Exit router mode.
PE1(config)# router bgp 1000	Configure router BGP in AS 1000
PE1(config-router)# neighbor cafe:1:2::22 remote-as 1000	Configure neighbor in remote-as 1000
PE1(config-router)#neighbor cafe:1:2::22 update-source lo	Configure neighbor with update-source lo
PE1(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE1(config-router-af)# segment-routing srv6	Enter SR6 mode
PE1(config-router-vpnv4-srv6)# srv6-locator srs123	Configure locator name under srv6 mode
PE1(config-router-vpnv4-srv6)# exit-srv6	Exit SRv6 mode
PE1(config-router-af)#neighbor cafe:1:2::22 activate	Activate VPNv4 neighbor
PE1(config-router-af)# neighbor cafe:1:2::22 capability extended-nexthop- encode	Configure extended nexthop encode capability for vpnv4 neighbor
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#address-family ipv4 vrf vrf1	Enter VRF address family
PE1(config-router-af)#redistribute	Redistribute connected routes

connected	
PE1(config-router-af)#segment-routing srv6	Enter SRv6 mode
PE1(config-router-vrfv4-srv6)#sid-alloc per-vrf	Allocate sid per VRF
PE1(config-router-vrfv4-srv6)#exit-srv6	Exit SRv6 mode
PE1(config-router-vrfv4-srv6)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router-af)#exit	Exit from router mode
PE1(config)#segment-routing	Configuring segment-routing
PE1(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
PE1(config-srv6)#locators	Configure SRv6 locators
PE1(config-srv6-loc)#locator srs123	Locator name as Srs123
PE1(config-srv6-loc-conf)# prefix cafe:1:2:a11::/64	IPv6 prefix for locator
PE1(config-srv6-loc-conf)#exit-locator	Exit from locator mode
PE1(config-srv6-loc)#exit-locators	Exit from SRv6 locators configuration mode
PE1(config-srv6)#exit-srv6	Exit from SRv6 configuration mode
PE1(config-sr)#traffic-engineering	Segment Routing traffic engineering
Segment Routing traffic engineering	Configure segment list as 1
PE1(config-sr-sl)#index 1 segment-type-2 cafe:1:2:a22:2001::	Configure segment type 2 with SRv6 SIDs
PE1(config-sr-sl)#exit-sr-sl	Exit segment list mode
PE1(config-sr-te)#policy 1	Policy configuration with name 1
PE1(config-sr-pol)# color 1 end-point cafe:1:2::22	SR-policy color and end-point
PE1(config-sr-pol-cp)#candidate-path 1	SR policy candidate path
PE1(config-sr-pol-cp)#preference 100	Candidate Path preference
PE1(config-sr-pol-cp)# explicit segment-list 1	Dynamic candidate path as OSPF
PE1(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode
PE1(config-sr-te)#exit-te	Exit from traffic engineering configuration mode

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface eth1	Enter interface mode.
P1(config-if)# ipv6 address 1111::1/64	Configure the IPv6 address of the interface.
P1(config-if)#ipv6 router ospf area 0.0.0.0	Make the interface part of the router ospf area 0.

tag 1 instance-id 0	
P1(config)#interface eth2	Enter interface mode.
P1(config-if)# ipv6 address 5001::1/64	Configure the IP address of the interface.
P1(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P1(config-if)#exit	Exit interface mode.
P1(config)#router ipv6 ospf 1	Set the routing process ID as 1
P1(config-router)#segment-routing srv6	Enable SRv6 under IPv6 address-family
PE1(config-router-af-srv6)# srv6-locator srs123	Name to SRv6 locator
P1(config-router)#exit	Exit router mode.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface eth1	Enter interface mode.
P2(config-if)# ipv6 address 50::50/64	Configure the IPv6 address of the interface.
P2(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P2(config)#interface eth2	Enter interface mode.
P2(config-if)# ipv6 address 5001::2/64	Configure the IP address of the interface.
P2(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ipv6 ospf 1	Set the routing process ID as 1
P2(config-router)#segment-routing srv6	Configure is-type as level-2
P2(config-router-af-srv6)#srv6-locator srs123	Name to SRv6 locator
P2(config-router)#exit	Exit router mode.

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface eth1	Enter interface mode.

P3(config-if)# ipv6 address 50::5/64	Configure the IPv6 address of the interface.
P3(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)# ipv6 address 511::1/64	Configure the IP address of the interface.
P3(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P3(config-if)#exit	Exit interface mode.
P3(config)#router ipv6 ospf 1	Set the routing process ID as 1
P3(config-router)#segment-routing srv6	Configure is-type as level-2
P3(config-router-af-srv6)#srv6-locator srs123	Name to SRv6 locator
P3(config-router)#exit	Exit router mode.

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)# ipv6 address 611::1/64	Configure the IPv6 address of the interface.
P4(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)# ipv6 address 511::2/64	Configure the IP address of the interface.
P4(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P4(config-if)#exit	Exit interface mode.
P4(config)#router ipv6 ospf 1	Set the routing process ID as 1
P4(config-router)#segment-routing srv6	Configure is-type as level-2
P4(config-router-af-srv6)#srv6-locator srs123	Name to SRv6 locator
P4(config-router)#exit	Exit router mode.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#tunnel-policy policy0	Configure tunnel policy

PE2(config-tnl-policy)#color 1	Color to be used as 1
PE2(config-tnl-policy)#exit	Exit to config mode
PE2(config)#ip vrf vrf1	IP VRF config with name vrf1
PE2(config-vrf)#tunnel-select-policy policy0	tunnel-policy to be mapped as policy0
PE2(config-vrf)#rd 1:2	Route-distinguisher value
PE2(config-vrf)#route-target both 1:1	Route target value
PE2(config-vrf)#exit	Exit to config mode
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)# ip address 6.6.6.6/32 secondary	Configure ip address on the loopback interface as secondary
PE2(config-if)#ipv6 address cafe:1:2::22/128	Configure IPv6 address of the loopback interface.
PE2(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth1	Enter interface mode.
PE2(config-if)#ipv6 address 611::2/64	Configure the IPv6 address of the interface.
PE2(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
PE2(config)#interface eth2	Enter interface mode.
PE2(config-if)#ip vrf forwarding vrf1	Attaching eth2 to as part of vrf1
PE2(config-if)#ip address 201.1.1.1/24	Configure the IP address of the interface.
PE2(config-if)#exit	Exit interface mode
PE2(config)#router ipv6 ospf 1	Set the routing process ID as 1
PE2(config-router)#segment-routing srv6	Configure is-type as level-2
PE2(config-router-af-srv6)#srv6-locator srs123	Name to SRv6 locator
PE2(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE2(config-router)#exit	Exit router mode.
PE2(config)# router bgp 1000	Configure router BGP in AS 1000
PE2(config-router)# neighbor cafe:1:2::11 remote-as 1000	Configure neighbor in remote-as 1000
PE2(config-router)#neighbor cafe:1:2::11 update-source lo	Configure neighbor with update-source lo
PE2(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE2(config-router-af)# segment-routing srv6	Enter SRv6 mode
PE2(config-router-vpnv4-srv6)# srv6-locator PE2_locator	Configure locator name under SRv6 mode

PE2(config-router-vpn4-srv6) # exit-srv6	Exit SRv6 mode
PE2(config-router-af) #neighbor cafe:1:2::11 activate	Activate VPNv4 neighbor
PE2(config-router-af) # neighbor cafe:1:2::11 capability extended-nexthop- encode	Configure extended nexthop encode capability for VPNv4 neighbor
PE2(config-router-af) #exit-address-family	Exit from Address Family configuration mode
PE2(config-router) #address-family ipv4 vrf vrf1	Enter VRF address family
PE2(config-router-af) #redistribute connected	Redistribute connected routes
PE2(config-router-af) #segment-routing srv6	Enter SRv6 mode
PE2(config-router-vrfv4-srv6) #sid-alloc per-vrf	Allocate sid per VRF
PE2(config-router-vrfv4-srv6) #exit-srv6	Exit SRv6 mode
PE2(config-router-vrfv4-srv6) #exit-address- family	Exit from Address Family configuration mode
PE2(config-router-af) #exit	Exit from router mode
PE2(config) #segment-routing	Configuring segment-routing
PE2(config-sr) #srv6	Segment-Routing over IPv6 Data-Plane
PE2(config-srv6) #locators	Configure SRv6 locators
PE2(config-srv6-loc) #locator srs123	Locator name as PE2_locator
PE2(config-srv6-loc-conf) # prefix cafe:1:2:a11::/64	IPv6 prefix for locator
PE2(config-srv6-loc-conf) #exit-locator	Exit from locator mode
PE2(config-srv6-loc) #exit-locators	Exit from SRv6 locators configuration mode
PE2(config-srv6) #exit-srv6	Exit from SRv6 configuration mode
PE2(config-sr) #traffic-engineering	Segment Routing traffic engineering
PE2(config-sr-sl) #segment-list 1	Configure segment list as 1
PE2(config-sr-sl) #index 1 segment-type-2 cafe:1:2:a22:2001::	Configure segment type 2 with SRv6 SIDs
PE2(config-sr-sl) #exit-sr-sl	Exit segment list mode
PE2(config-sr-te) #policy 1	Policy configuration with name 1
PE2(config-sr-pol) # color 1 end-point cafe:1:2::11	SR-policy color and end-point
PE2(config-sr-pol-cp) #candidate-path 1	SR policy candidate path
PE2(config-sr-pol-cp) #preference 100	Candidate Path preference
PE2(config-sr-pol-cp) # explicit segment- list 1	Configuring explicit segment-list as 1
PE2(config-sr-pol) #exit-sr-pol	Exit from SR policy configuration mode
PE2(config-sr-te) #exit-te	Exit from traffic engineering configuration mode

Validation

PE1

Validation on PE1 Router

```

PE1-7028#show ipv6 ospf neighbor

Total number of full neighbors: 1
OSPFv3 Process (1)
Neighbor ID      Pri   State           Dead Time   Interface   Instance ID
2.2.2.2          1    Full/DR         00:00:31    ce0         0

PE1-7028#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,
       P - SRV6-POLICY,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C    ::1/128 via ::, lo, 00:56:23
O    50::/64 [110/3] via fe80::ba6a:97ff:fed6:716e, ce0, 00:02:17
O    102::/64 [110/6] via fe80::ba6a:97ff:fed6:716e, ce0, 00:01:43
O    511::/64 [110/4] via fe80::ba6a:97ff:fed6:716e, ce0, 00:01:43
C    567::/64 via ::, ce0, 00:03:03
O    611::/64 [110/5] via fe80::ba6a:97ff:fed6:716e, ce0, 00:01:43
O    1234::/64 [110/2] via fe80::ba6a:97ff:fed6:716e, ce0, 00:02:17
O    3234::/64 [110/5] via fe80::ba6a:97ff:fed6:716e, ce0, 00:01:43
O    5001::/64 [110/2] via fe80::ba6a:97ff:fed6:716e, ce0, 00:02:17
C    cafe:1:2::11/128 via ::, lo, 00:55:51
O    cafe:1:2::22/128 [110/5] via fe80::ba6a:97ff:fed6:716e, ce0, 00:01:43
O    cafe:1:2:a11::/64 [110/1] via ::, lo, 00:02:23
C    cafe:1:2:a11:801::/128, SRV6 END SID
    via ::, lo, 00:55:51
C    cafe:1:2:a11:1001::/128, SRV6 END SID
    via ::, lo, 00:55:51
C    cafe:1:2:a11:2001::/128, SRV6 END SID
    via ::, lo, 00:55:51
C    cafe:1:2:a11:2003::/128, SRV6 END.X SID
    via fe80::ba6a:97ff:fed6:716e, ce0, 00:02:23
C    cafe:1:2:a11:8001::/128, SRV6 END.DT4 SID
    via ::, lo, 00:55:51
O    cafe:1:2:a22::/64 [110/6] via fe80::ba6a:97ff:fed6:716e, ce0, 00:01:43
C    fe80::/64 via ::, ce0, 00:03:03

PE1-7028#show ipv6 ospf database

                OSPFv3 Router with ID (1.1.1.1) (Process 1)

                Link-LSA (Interface lo)

Link State ID    ADV Router      Age      Seq#           CkSum  Prefix
0.0.0.1          1.1.1.1         64       0x80000003    0x9f63    2

                Link-LSA (Interface ce0)

Link State ID    ADV Router      Age      Seq#           CkSum  Prefix
0.0.39.151      1.1.1.1         496      0x80000001    0x0449    1
0.0.39.65       2.2.2.2         497      0x80000001    0xcf29    1

```

Router-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum	Link
0.0.0.0	1.1.1.1	416	0x80000009	0x1aa8	1
0.0.0.0	2.2.2.2	452	0x80000008	0x6b13	2
0.0.0.0	3.3.3.3	712	0x80000006	0x2452	2
0.0.0.0	4.4.4.4	709	0x80000004	0xabbf	2
0.0.0.0	5.5.5.5	713	0x80000008	0x5f3d	2
0.0.0.0	6.6.6.6	421	0x8000000d	0x064b	1

Network-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum
0.0.39.65	2.2.2.2	457	0x80000001	0xf496
0.0.39.21	3.3.3.3	1799	0x80000002	0xe2c7
0.0.39.66	3.3.3.3	713	0x80000001	0x85f0
0.0.39.22	5.5.5.5	713	0x80000001	0x474b
0.0.39.17	6.6.6.6	5	0x80000003	0xabdd

Intra-Area-Prefix-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum	Prefix	Reference
0.0.0.1	1.1.1.1	415	0x8000000a	0x70e5	2	Router-LSA
0.0.0.1	2.2.2.2	451	0x8000000a	0x6bf9	1	Router-LSA
0.0.0.2	2.2.2.2	451	0x80000001	0x5c82	1	Network-LSA
0.0.0.2	3.3.3.3	1794	0x80000002	0x4bd1	1	Network-LSA
0.0.0.4	3.3.3.3	712	0x80000001	0x39b6	1	Network-LSA
0.0.0.1	5.5.5.5	712	0x80000009	0x0c22	1	Router-LSA
0.0.0.2	5.5.5.5	712	0x80000001	0x2a1e	1	Network-LSA
0.0.0.1	6.6.6.6	420	0x8000000e	0xd7de	3	Router-LSA
0.0.0.2	6.6.6.6	20	0x80000003	0xf7ce	1	Network-LSA
0.0.0.3	6.6.6.6	1798	0x80000002	0x132f	1	Network-LSA

Opaque-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum
0.0.0.0	1.1.1.1	456	0x80000004	0x6741
0.0.0.0	6.6.6.6	5	0x80000006	0xcc5

Ext-Router-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum
0.0.39.151	1.1.1.1	456	0x80000001	0x9a3a
0.0.39.171	1.1.1.1	456	0x80000003	0xacfa
0.0.39.17	6.6.6.6	3600	0x80000003	0x6e60
0.0.39.37	6.6.6.6	3600	0x80000003	0x0a99
19.138.128.101	6.6.6.6	3600	0x80000003	0x10bd

Locator-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum
0.0.39.151	1.1.1.1	456	0x80000001	0x2679
0.0.39.171	1.1.1.1	456	0x80000003	0x5930
0.0.39.17	6.6.6.6	3600	0x80000003	0x4487
0.0.39.37	6.6.6.6	3600	0x80000003	0x7b3c
19.138.128.101	6.6.6.6	3600	0x80000003	0xabd4

PE1-7028#show segment-routing srv6 locator srs123 detail

Locator : srs123

Prefix : cafe:1:2:a11::/64

Uptime : 01:01:44

PE1-7028#show ipv6 ospf database opaque

OSPFv3 Router with ID (1.1.1.1) (Process 1)

Opaque-LSA (Area 0.0.0.0)

```
LS age: 569
LS Type: Opaque RI LSA
Link State ID: 0.0.0.0
Advertising Router: 1.1.1.1
LS Seq Number: 0x80000004
Checksum: 0x6741
Length: 48

Router Capability TLV:
Flags:0   Reserve bits:0

Algorithm TLV :
  Algorithm: 0

Maximum SID Depth :
SRH maximum segments left (41) : 4
SRH maximum end pop (42) : 4
SRH maximum H.encaps (44) : 4
SRH maximum decapsulation sids (45) : 4

LS age: 118
LS Type: Opaque RI LSA
Link State ID: 0.0.0.0
Advertising Router: 6.6.6.6
LS Seq Number: 0x80000006
Checksum: 0xCCC5
Length: 48

Router Capability TLV:
Flags:0   Reserve bits:0

Algorithm TLV :
  Algorithm: 0

Maximum SID Depth :
SRH maximum segments left (41) : 4
SRH maximum end pop (42) : 4
SRH maximum H.encaps (44) : 4
SRH maximum decapsulation sids (45) : 4

PE1-7028#show ipv6 ospf database locator

      OSPFv3 Router with ID (1.1.1.1) (Process 1)

          Locator-LSA (Area 0.0.0.0)

LS age: 586
LS Type: Locator LSA
Link State ID: 0.0.39.151
Advertising Router: 1.1.1.1
LS Seq Number: 0x80000001
Checksum: 0x2679
Length: 120

Locator-LSA (Length:24):
  Route type:0   Algorithm:0
  Flags:0       Metric:0
  Prefix: cafe:1:2:all::/64

SRv6 END TLV (Length:20):
  Flags:0       Reserved:0
  END SID: cafe:1:2:all:2001::
  End-point behaviour: End with PSP (2)

SRv6 END TLV (Length:20):
  Flags:0       Reserved:0
  END SID: cafe:1:2:all:1001::
```

```
End-point behaviour: End with USP (3)

SRv6 END TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a11:801::
  End-point behaviour: End with USD (28)

LS age: 586
LS Type: Locator LSA
Link State ID: 0.0.39.171
Advertising Router: 1.1.1.1
LS Seq Number: 0x80000003
Checksum: 0x5930
Length: 120

Locator-LSA (Length:24):
  Route type:0      Algorithm:0
  Flags:0      Metric:0
  Prefix: cafe:1:2:a11::/64

SRv6 END TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a11:2001::
  End-point behaviour: End with PSP (2)

SRv6 END TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a11:1001::
  End-point behaviour: End with USP (3)

SRv6 END TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a11:801::
  End-point behaviour: End with USD (28)

LS age: 135
LS Type: Locator LSA
Link State ID: 0.0.39.17
Advertising Router: 6.6.6.6
LS Seq Number: 0x80000004
Checksum: 0x4288
Length: 120

Locator-LSA (Length:24):
  Route type:0      Algorithm:0
  Flags:0      Metric:0
  Prefix: cafe:1:2:a22::/64

SRv6 END TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a22:2001::
  End-point behaviour: End with PSP (2)

SRv6 END TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a22:1001::
  End-point behaviour: End with USP (3)

SRv6 END TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a22:801::
  End-point behaviour: End with USD (28)
```



```

LS age: 135
LS Type: Locator LSA
Link State ID: 0.0.39.37
Advertising Router: 6.6.6.6
LS Seq Number: 0x80000004
Checksum: 0x793D
Length: 120

Locator-LSA (Length:24):
  Route type:0    Algorithm:0
  Flags:0        Metric:0
  Prefix: cafe:1:2:a22::/64

SRv6 END TLV (Length:20):
  Flags:0        Reserved:0
  END SID: cafe:1:2:a22:2001::
  End-point behaviour: End with PSP (2)

SRv6 END TLV (Length:20):
  Flags:0        Reserved:0
  END SID: cafe:1:2:a22:1001::
  End-point behaviour: End with USP (3)

SRv6 END TLV (Length:20):
  Flags:0        Reserved:0
  END SID: cafe:1:2:a22:801::
  End-point behaviour: End with USD (28)

```

```

LS age: 135
LS Type: Locator LSA
Link State ID: 19.138.128.101
Advertising Router: 6.6.6.6
LS Seq Number: 0x80000004
Checksum: 0xA9D5
Length: 120

Locator-LSA (Length:24):
  Route type:0    Algorithm:0
  Flags:0        Metric:0
  Prefix: cafe:1:2:a22::/64

SRv6 END TLV (Length:20):
  Flags:0        Reserved:0
  END SID: cafe:1:2:a22:2001::
  End-point behaviour: End with PSP (2)

SRv6 END TLV (Length:20):
  Flags:0        Reserved:0
  END SID: cafe:1:2:a22:1001::
  End-point behaviour: End with USP (3)

SRv6 END TLV (Length:20):
  Flags:0        Reserved:0
  END SID: cafe:1:2:a22:801::
  End-point behaviour: End with USD (28)

```

```

PE1-7028#sho ip bgp vpnv4 all summary
BGP router identifier 11.11.11.11, local AS number 1000
BGP table version is 2
1 BGP AS-PATH entries
0 BGP community entries

```

Neighbor	V	AS	MsgRcv	MsgSen	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
cafe:1:2::22	4	1000	150	150	2	0	0	01:02:47	1

Total number of neighbors 1

Total number of Established sessions 1

PE1-7028#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 vrf1)					
*> 101.1.1.0/24	0.0.0.0	0	100	32768	?
*>i201.1.1.0	cafe:1:2::22	0	100	0	?
Announced routes count = 1					
Accepted routes count = 1					
Route Distinguisher: 1:1					
*>i201.1.1.0	cafe:1:2::22	0	100	0	?
Announced routes count = 0					
Accepted routes count = 1					

PE1-7028#show ip bgp vpnv4 all tags

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	In Label/Out Label
Route Distinguisher: 1:1 (Default for VRF vrf1)		
*> 101.1.1.0/24	0.0.0.0	Local sid cafe:1:2:a11:8001::
*>i 201.1.1.0	cafe:1:2::22	vpn sid cafe:1:2:a22:8001::
Announced routes count = 1		
Accepted routes count = 1		
Route Distinguisher: 1:1		
*>i 201.1.1.0	cafe:1:2::22	
Announced routes count = 0		
Accepted routes count = 1		

PE1-7028#

PE1-7028#show segment-routing srv6 sid

SRv6 Segment ID table:

SID	Operation	Nexthop	Originator
cafe:1:2:a11:801::	END[usd]	::	nsm
cafe:1:2:a11:1001::	END[usp]	::	nsm
cafe:1:2:a11:2001::	END[psp]	::	nsm
cafe:1:2:a11:2003::	END.X[psp]	fe80::ba6a:97ff:fed6:716e	ospf
cafe:1:2:a11:8001::	END.DT4	vrf vrf1	bgp:1000

PE1-7028#show segment-routing srv6 services

Codes: > - installed; T:Uses service-mapped tunnel

Service Flags

vrf	FEC	SID	Nexthop	SRv6-
Policy-Name				
vpnv4	>*T vrf1	201.1.1.0/24	cafe:1:2:a22:8001::	cafe:1:2::22
p1				

PE1-7028#show hsl srv6 l3vpn

TABLE: SRV6 L3VPN

VRF	DESTINATION	POLICY/LSP/	OUT	VPN	NEXTHOP
NEXTHOP	Number of	SEGMENTS			
ID	FEC	TYPE/NHLFE ID	IFNAME		
			Segments		
2	201.1.1.0/24	1 /3 /PRI			
/3	ce0	cafe:1:2::22	fe80::ba6a:97ff:fed6:716e	1	cafe:1:2:a

22:8001::

User Defined Adjacency SID for ISIS or OSPF

Overview

This section provides an overview of user-defined Adjacency Segment Identifiers (Adj-SIDs) in Intermediate System to Intermediate System Segment Routing (ISIS-SR) or Open Shortest Path First (OSPF) environments.

SR is a modern forwarding paradigm that enables advanced traffic engineering (TE) by encoding path information within packet headers using segment identifiers (SIDs). SR-TE tunnels can be:

- Manually provisioned on the tunnel headend, or
- Dynamically computed and programmed by a centralized controller.

To implement SR-TE effectively, traffic must often be steered through specific nodes or links within the network:

- Prefix-SID is used to route traffic through a specific node.
- Adjacency SID (Adj-SID) enforces routing over a particular link.

Default Behavior

By default, IS-IS or OSPF dynamically allocates adjacency SIDs. These dynamic values:

- Are not persistent across reloads or process restarts.
- It cannot be predicted in advance.
- Require real-time IGP database access by controllers.

Due to these limitations, user-defined (static) adjacency SIDs are introduced to offer deterministic, persistent SID values, enabling efficient and controlled SR path computation.

Benefits

Implementing user-defined adjacency SIDs in IS-IS SR networks offers several advantages:

- Deterministic SID Allocation: users can assign fixed, known SIDs to specific links.
- Persistent Across Reloads: static SIDs retain its value even after reboots or process restarts.
- Controller-Friendly: simplifies path computation for external SDN controllers or SR orchestration.
- Improved Traffic Engineering: enables precise control of SR path selection across specific links.
- Simplified Troubleshooting: known SID values improve visibility and operational consistency.

OSPF Configuration

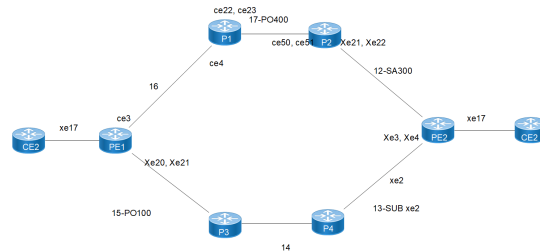
Configure OSPF with Segment Routing, assign user-defined Adj-SIDs to specific interfaces, and set up SR-TE tunnels from PE1 (headend) to PE2 (tailend) to enable deterministic traffic engineering across the core network.

Topology

This topology illustrates the OSPF Adj-SID feature in a SR-enabled network. It includes two Provider Edge (PE) routers, PE1 and PE2, connected through two redundant paths: P1 and P2, and via P3 and P4. By default, OSPF

may install both paths as Equal-Cost Multi-paths (ECMP). To enforce traffic over a specific path, such as the route through P1 and P2, Adj-SIDs are assigned to the PE1–P1, P1–P2, and P2–PE2 links. PE1 can then insert these Adj-SIDs into the SR label stack, ensuring deterministic forwarding along the intended path. This mechanism allows precise traffic steering independent of IGP shortest-path decisions, enabling better traffic engineering, fast reroute, and SLA compliance.

Figure 21. L2VPN with SRLB-SID-ADJ configuration topology



The following steps describe to configure user-defined adjacency SIDs in an OSPF-SR environment for deterministic traffic engineering.

- a. Enable Segment Routing to define the label blocks used for Prefix-SID and Adjacency-SID:

```
#configure terminal
(config)#segment-routing
(config-sr)#global block 10001 20000
(config-sr)#local block 100000 109999
```

- b. Configure the loopback interface with a Prefix-SID to identify the router globally in the SR domain:

```
(config)#interface lo
(config-if)#ip address 43.43.43.43/32 secondary
(config-if)#prefix-sid index 4300
(config-if)#commit
(config-if)#exit
```

- c. Configure LDP to ensure compatibility with non-SR MPLS devices and to maintain dual-protocol support:

```
(config)#router ldp
(config-router)#router-id 43.43.43.43
(config-router)#targeted-peer ipv4 14.14.14.14
(config-router-targeted-peer)#exit-targeted-peer-mode
(config-router)#transport-address ipv4 43.43.43.43
(config-router)#commit
(config-router)#exit
```

- d. Configure the interfaces with an Adjacency SID using an absolute value to enable fine-grained control over the forwarding path:

```
(config)#interface ce3
(config-if)#ip address 16.0.0.10/24
(config-if)#adjacency-sid ospf absolute 100500
(config-if)#ip ospf network point-to-point
(config-if)#label-switching
(config-if)#enable-ldp ipv4
(config-if)#commit
(config-if)#exit
```

- e. Configure the PO100 interface with an Adjacency SID using an index to assign a label from the local block dynamically:

```
(config)#interface po100
(config-if)#ip address 15.0.0.20/24
```

```
(config-if)#adjacency-sid ospf index 501
(config-if)#ip ospf network point-to-point
(config-if)#label-switching
(config-if)#enable-ldp ipv4
(config-if)#commit
(config-if)#exit
```

f. Create a port-channel to bundle physical interfaces and increase bandwidth and resiliency:

```
(config-if)#interface xe20
(config-if)#channel-group 100 mode active
(config-if)#exit
(config-if)#interface xe21
(config-if)#channel-group 100 mode active
(config-if)#exit
```

g. Configure OSPF with Segment Routing enabled to advertise SIDs through the IGP:

```
(config)#router ospf 100
(config-router)#ospf router-id 43.43.43.43
(config-router)#network 15.0.0.20/24 area 0
(config-router)#network 16.0.0.10/24 area 0
(config-router)#network 43.43.43.43/32 area 0
(config-router)#segment-routing mpls
(config-router)#commit
(config-router)#exit
```

h. Define an SR Policy to steer traffic dynamically based on constraints for traffic engineering:

```
(config)#tunnel-policy PE1-P1-PE2
(config-tnl-policy)# color 1
(config)#tunnel-policy PE1-P3-PE2
(config-tnl-policy)# color 2
(config)#segment-routing
(config-sr)# traffic-engineering
(config-sr-te) policy PE1-P1-PE2
(config-sr-pol) color 1 end-point 14.14.14.14
(config-sr-pol-cp) candidate-path 1
(config-sr-pol-cp)# dynamic-path ospf 1
(config-sr-pol-cp)# constraints
(config-sr-dyn-cp-cons)# 16.0.0.20 strict
(config-sr-dyn-cp-cons)# 17.0.0.20 strict
(config-sr-dyn-cp-cons)# 12.0.0.10 strict
(config-sr-pol-cp)# exit-pol-cp
(config-sr-pol)#exit-sr-pol
```

i. Configure VRFs to define tenant-specific routing tables and isolate routing instances per service:

```
(config)#mac vrf vrf500
(config-vrf)#rd 43.43.43.43:500
(config-vrf)#route-target both 500:500
(config)#mac vrf vpls600
(config-vrf)#rd 43.43.43.43:600
(config-vrf)#route-target both 600:600
(config)#mac vrf vrfetree700
(config-vrf)#rd 101:1
(config-vrf)#route-target export 101:1
(config-vrf)#route-target import 102:1
```

j. Map VTEP to loopback IP to ensure loopback-reachability across the EVPN MPLS fabric:

```
(config-vrf)#evpn mpls vtep-ip-global 43.43.43.43
```

k. Configure EVPN instances for ELINE, ELAN, and ETREE services to enable L2 VPN delivery over MPLS using BGP-EVPN signaling:

```
(config)#evpn mpls id 2 xconnect target-mpls-id 252
and target identifier
```

```
(config)#host-reachability-protocol evpn-bgp vrf500
(config)#evpn mpls id 600
(config)#host-reachability-protocol evpn-bgp vpls600
(config)#evpn mpls id 700
(config)#host-reachability-protocol evpn-bgp vrfetree700
```

l. Configure BGP EVPN peering to advertise EVPN routes and establish control-plane reachability between PEs:

```
(config)#router bgp 100
(config-router)#bgp router-id 43.43.43.43
(config-router)#neighbor 14.14.14.14 remote-as 100
(config-router)#neighbor 14.14.14.14 update-source lo
(config-router)#address-family vpnv4 unicast
(config-router-af)#neighbor 14.14.14.14 activate
(config-router-af)#exit-address-family
(config-router)#address-family l2vpn evpn
(config-router-af)#neighbor 14.14.14.14 activate
(config-router-af)#exit-address-family
(config-router)#exit
```

m. Configure a VPLS instance to deliver Ethernet multipoint services using LDP-based signaling:

```
(config)#mpls vpls100 100
(config-vpls)#signaling ldp
(config-vpls-sig)#vpls-type ethernet
(config-vpls-sig)# vpls-peer 14.14.14.14 tunnel-select-policy PE1-P3-PE2
(config-vpls-sig)#exit-signaling
(config-vpls)#exit-vpls
```

n. Configure a VPWS instance to deliver point-to-point Ethernet services using SR policy as a tunnel selector:

```
(config)#mpls l2-circuit VPWS200 200 14.14.14.14
(config-pseudowire)# tunnel-select-policy PE1-P5-PE2
```

o. Configure BGP-signaled VPLS instance for enhanced scaling and control-plane signaling using BGP:

```
(config)#mpls vpls BGP-VPLS-PE1-PE2-300 300
(config-vpls)#signaling bgp
(config-vpls-sig)#ve-id 500
(config-vpls-sig)#exit-signaling
(config-vpls)#exit-vpls
```

p. Associate service instances to subinterfaces using Dot1Q encapsulation to map VLANs to specific L2VPN services:

```
(config-if)#interface xel7.100 switchport
(config-if)#encapsulation dot1q 100
(config-if)#access-if-vpls
(config-acc-if-vpls)#mpls-vpls vpls100
(config-if)#interface xel7.200 switchport
(config-if)#encapsulation dot1q 200
(config-if)#access-if-vpws
(config-acc-if-vpls)#mpls-vpws VPWS100
(config-if)#interface xel7.300 switchport
(config-if)#encapsulation dot1q 300
(config-if)#access-if-vpls
(config-acc-if-vpls)#mpls-vpls BGP-VPLS-PE1-PE2-300
(config-if)#interface xel7.500 switchport
(config-if)#encapsulation dot1q 500
(config-if)#access-if-evpn
(config-acc-if-vpls)#map vpn-id 2
(config-if)#interface xel7.600 switchport
(config-if)#encapsulation dot1q 600
(config-if)#access-if-evpn
(config-acc-if-vpls)#map vpn-id 600
(config-if)#interface xel7.700 switchport
(config-if)#encapsulation dot1q 700
```

```
(config-if)#access-if-evpn
(config-acc-if-vpls)#map vpn-id 700
(config-acc-if-vpls)#commit
(config-acc-if-vpls)#end
```

Configuration Snapshot

PE1

The following are the configuration snapshot on the PE1 router.

```
!
hostname PE1
!
interface Loopback0
 ip address 43.43.43.43 255.255.255.255
!
interface ce3
 ip address 16.0.0.10 255.255.255.0
 ip ospf network point-to-point
 mpls ip
 mpls ldp enable
!
interface Port-channel100
 ip address 15.0.0.20 255.255.255.0
 adjacency-sid ospf index 501
 ip ospf network point-to-point
 mpls ip
 mpls ldp enable
!
interface TenGigabitEthernet0/0/0
 channel-group 100 mode active
!
interface TenGigabitEthernet0/0/1
 channel-group 100 mode active
!
interface TenGigabitEthernet0/0/2.100
 encapsulation dot1Q 100
 xconnect vfi vpls100
!
interface TenGigabitEthernet0/0/2.200
 encapsulation dot1Q 200
 xconnect VPWS200
!
interface TenGigabitEthernet0/0/2.300
 encapsulation dot1Q 300
 xconnect vfi BGP-VPLS-PE1-PE2-300
!
interface TenGigabitEthernet0/0/2.500
 encapsulation dot1Q 500
 evpn
 evpn instance 2
!
interface TenGigabitEthernet0/0/2.600
 encapsulation dot1Q 600
 evpn
 evpn instance 600
!
interface TenGigabitEthernet0/0/2.700
 encapsulation dot1Q 700
 evpn
 evpn instance 700
!
mpls label range 10001 20000
```



```
mpls ldp router-id Loopback0 force
mpls ldp
!
segment-routing
  global block 10001 20000
  local block 100000 109999
traffic-engineering
segment-list SID_LIST_1
  index 1 segment-type-1 100501
  index 2 segment-type-1 41599
  index 3 segment-type-1 45900
exit-sr-sl
!
policy PE1-P1-P2-PE2
color 1 end-point 14.14.14.14
candidate-path 1
dynamic-path ospf 1
constraints
16.0.0.20 strict
17.0.0.20 strict
12.0.0.10 strict
exit-pol-cp
exit-sr-pol
policy PE1-P3-P4-PE2
color 2 end-point 14.14.14.14
candidate-path 1
explicit segment-list SID_LIST_1
exit-pol-cp
exit-sr-pol
!
router ospf 100
  router-id 43.43.43.43
  network 15.0.0.0 0.0.0.255 area 0
  network 16.0.0.0 0.0.0.255 area 0
  network 43.43.43.43 0.0.0.0 area 0
  segment-routing mpls
!
router bgp 100
  bgp router-id 43.43.43.43
  neighbor 14.14.14.14 remote-as 100
  neighbor 14.14.14.14 update-source Loopback0
  !
  address-family vpnv4
    neighbor 14.14.14.14 activate
  exit-address-family
  !
  address-family l2vpn evpn
    neighbor 14.14.14.14 activate
  exit-address-family
  !
l2vpn vfi context vpls100
  vpn id 100
  bridge-domain 100
  autodiscovery ldp
  neighbor 14.14.14.14
  !
l2vpn vfi context BGP-VPLS-PE1-PE2-300
  vpn id 300
  bridge-domain 300
  autodiscovery bgp
  ve-id 500
  !
l2vpn xconnect context VPWS200
  vpn id 200
  neighbor 14.14.14.14
  !
evpn
  vtep ip 43.43.43.43
```

```
!  
evpn instance 2  
  rd 43.43.43.43:500  
  route-target import 500:500  
  route-target export 500:500  
!  
evpn instance 600  
  rd 43.43.43.43:600  
  route-target import 600:600  
  route-target export 600:600  
!  
evpn instance 700  
  rd 101:1  
  route-target import 102:1  
  route-target export 101:1  
!
```

P1

The following are the configuration snapshot on the P1 router.

```
segment-routing  
  global block 10001 20000  
  local block 30000 36000  
!  
  
interface lo  
  ip address 5.5.5.5 255.255.255.255 secondary  
  prefix-sid index 3000  
!  
  
router ldp  
  router-id 5.5.5.5  
!  
  
interface ce4  
  ip address 16.0.0.20 255.255.255.0  
  label-switching  
  ip ospf network point-to-point  
  adjacency-sid ospf index 1000  
!  
  
interface Po400  
  ip address 17.0.0.10 255.255.255.0  
  label-switching  
  ip ospf network point-to-point  
  adjacency-sid ospf absolute 30700  
!  
  
interface ce22  
  channel-group 400 mode active  
!  
  
interface ce23  
  channel-group 400 mode active  
!  
  
router ospf 100  
  router-id 5.5.5.5  
  network 17.0.0.0 0.0.0.255 area 0  
  network 16.0.0.0 0.0.0.255 area 0  
  network 5.5.5.5 0.0.0.0 area 0  
  segment-routing mpls  
!
```

P2

The following are the configuration snapshot on the P2 router.

```
!segment-routing
  global block 10001 20000
  local block 41000 50000
!

interface lo
  ip address 44.44.44.44 255.255.255.255 secondary
  prefix-sid index 4400
!

router ldp
  router-id 44.44.44.44
!

interface sa300
  ip address 12.0.0.10 255.255.255.0
  label-switching
  ip ospf network point-to-point
  adjacency-sid ospf index 45000
!

interface Po400
  ip address 17.0.0.20 255.255.255.0
  label-switching
  ip ospf network point-to-point
  adjacency-sid ospf index 2000
!

interface ce50
  channel-group 400 mode active
!

interface ce51
  channel-group 400 mode active
!

interface xe21
  static-channel-group 300
!

interface xe22
  static-channel-group 300
!

router ospf 100
  router-id 5.5.5.5
  network 17.0.0.0 0.0.0.255 area 0
  network 16.0.0.0 0.0.0.255 area 0
  network 5.5.5.5 0.0.0.0 area 0
  segment-routing mpls
!
```

P3

The following are the configuration snapshot on the P3 router.

```
segment-routing
  global block 10001 17000
  local block 41000 50000
!
```

```
interface lo
  ip address 42.42.42.42 255.255.255.255 secondary
  prefix-sid index 4200
!

router ldp
  router-id 42.42.42.42
!

interface Po100
  ip address 15.0.0.10 255.255.255.0
  label-switching
  ip ospf network point-to-point
  adjacency-sid ospf index 4159
!

interface xe9
  ip address 14.0.0.10 255.255.255.0
  label-switching
  ip ospf network point-to-point
  adjacency-sid ospf absolute 41599
!

interface xe20
  channel-group 100 mode active
!

interface xe21
  channel-group 100 mode active
!

router ospf 100
  router-id 42.42.42.42
  network 14.0.0.0 0.0.0.255 area 0
  network 15.0.0.0 0.0.0.255 area 0
  network 42.42.42.42 0.0.0.0 area 0
  segment-routing mpls
!
```

P4

The following are the configuration snapshot on the P4 router.

```
segment-routing
  global block 10001 20000
  local block 41000 50000
!

interface lo
  ip address 29.29.29.29 255.255.255.255 secondary
  prefix-sid index 2900
!

router ldp
  router-id 29.29.29.29
!

interface xe2.2000
  ip address 13.0.0.20 255.255.255.0
  label-switching
  ip ospf network point-to-point
  adjacency-sid ospf index 4900
!
```

```
interface xe9
  ip address 14.0.0.20 255.255.255.0
  label-switching
  ip ospf network point-to-point
  adjacency-sid ospf index 5000
!

router ospf 100
  router-id 5.5.5.5
  network 13.0.0.0 0.0.0.255 area 0
  network 14.0.0.0 0.0.0.255 area 0
  network 29.29.29.29 0.0.0.0 area 0
  segment-routing mpls
!
```

PE2

The following are the configuration snapshot on the PE2 router.

```
segment-routing
  global block 10001 20000
  local block 65000 74000
!

interface lo
  ip address 14.14.14.14 255.255.255.255 secondary
  prefix-sid index 1400
!

router ldp
  router-id 14.14.14.14
  targeted-peer ipv4 43.43.43.43
  transport-address ipv4 14.14.14.14
!

interface sa300
  ip address 12.0.0.10 255.255.255.0
  adjacency-sid ospf index 5000
  ip ospf network point-to-point
  label-switching
  enable-ldp ipv4
!

interface x2.2000
  ip address 13.0.0.10 255.255.255.0
  adjacency-sid ospf index 5001
  ip ospf network point-to-point
  label-switching
  enable-ldp ipv4
!

interface xe3
  static-channel-group 300
!

interface xe4
  channel-group 100 mode active
!

router ospf 100
  router-id 14.14.14.14
  network 12.0.0.0 0.0.0.255 area 0
  network 13.0.0.0 0.0.0.255 area 0
```

```
network 14.14.14.14 0.0.0.0 area 0
segment-routing mpls
!

tunnel-policy PE1-P1-PE2
color 1
!

tunnel-policy PE1-P3-PE2
color 2
!

segment-routing
traffic-engineering
policy PE1-P1-PE2
color 1 end-point 43.43.43.43
candidate-path 1
dynamic-path ospf 1
constraints
44.44.44.44 loose
30.30.30.30 loose
!

segment-routing
traffic-engineering
policy PE1-P3-PE2
color 2 end-point 43.43.43.43
candidate-path 1
dynamic-path ospf 1
constraints
29.29.29.29 loose
42.42.42.42 loose
!

mac vrf vrf500
rd 14.14.14.14:500
route-target both 500:500
!

mac vrf vpls600
rd 14.14.14.14:600
route-target both 600:600
!

mac vrf vrfetree700
rd 101:1
route-target export 101:1
route-target import 102:1
evpn mpls vtep-ip-global 14.14.14.14
!

evpn mpls id 252 xconnect target-mpls-id 2
!

host-reachability-protocol evpn-bgp vrf500
!

evpn mpls id 600
!

host-reachability-protocol evpn-bgp vpls600
!

evpn mpls id 700
!

host-reachability-protocol evpn-bgp vrfetree700
!
```

```
router bgp 100
  bgp router-id 14.14.14.14
  neighbor 43.43.43.43 remote-as 100
  neighbor 43.43.43.43 update-source lo
  address-family vpnv4 unicast
    neighbor 43.43.43.43 activate
  exit-address-family
  address-family l2vpn evpn
    neighbor 43.43.43.43 activate
  exit-address-family
!

mpls vpls100 100
  signaling ldp
  vpls-type ethernet
  vpls-peer 43.43.43.43 tunnel-select-policy PE1-P3-PE2
!

mpls l2-circuit VPWS200 200 43.43.43.43
  tunnel-select-policy PE1-P5-PE2
!

mpls vpls BGP-VPLS-PE1-PE2-300 300
  signaling bgp
  ve-id 500
!

interface xe17.100 switchport
  encapsulation dot1q 100
  access-if-vpls
  mpls-vpls vpls100
!

interface xe17.200 switchport
  encapsulation dot1q 200
  access-if-vpws
  mpls-vpws VPWS100
!

interface xe17.300 switchport
  encapsulation dot1q 300
  access-if-vpls
  mpls-vpls BGP-VPLS-PE1-PE2-300
!

interface xe17.500 switchport
  encapsulation dot1q 500
  access-if-evpn
  map vpn-id 252
!

interface xe17.600 switchport
  encapsulation dot1q 600
  access-if-evpn
  map vpn-id 600
!

interface xe17.700 switchport
  encapsulation dot1q 700
  access-if-evpn
  map vpn-id 700
!
```

Validation

PE1

The following are the validation on the PE1 router.

```

PE1#show ip ospf neighbor detail
Neighbor 42.42.42.42, interface address 15.0.0.10
  In the area 0.0.0.0 via interface po100
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:34
  Neighbor is detected for 00:20:31
  Neighbor is FULL for 00:20:31
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 27521
  Static adj sid: 100501
  Bidirectional Forwarding Detection is enabled

Neighbor 5.5.5.5, interface address 16.0.0.20
  In the area 0.0.0.0 via interface ce3
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:33
  Neighbor is detected for 00:28:15
  Neighbor is FULL for 00:28:15
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 27520
  Static adj sid: 100500
  Bidirectional Forwarding Detection is enabled

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

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      10       19000      3          N/A       ce3       16.0.
0.20      Yes     LSP_DEFAULT
B> evpn:600        2        640       Nolabel    N/A       N/A       127.0
.0.1      Yes     LSP_DEFAULT
B> evpn:600        3        17        Nolabel    N/A       N/A       127.0
.0.1      Yes     LSP_DEFAULT
B> evpn:2          1        16        Nolabel    N/A       N/A       127.0
.0.1      Yes     LSP_DEFAULT

```



```

B> evpn:900 7 19 Nolabel N/A N/A 127.0
.0.1 Yes LSP_DEFAULT
B> evpn:700 5 18 Nolabel N/A N/A 127.0
.0.1 Yes LSP_DEFAULT
B> evpn:1000 8 20 Nolabel N/A N/A 127.0
.0.1 Yes LSP_DEFAULT
B> evpn:900 6 642 Nolabel N/A N/A 127.0
.0.1 Yes LSP_DEFAULT
B> evpn:700 4 641 Nolabel N/A N/A 127.0
.0.1 Yes LSP_DEFAULT
O> 14.14.14.14/32 13 17400 17400 N/A po100 15.0.
0.10 Yes LSP_DEFAULT
O> 29.29.29.29/32 14 18900 18900 N/A po100 15.0.
0.10 Yes LSP_DEFAULT
P> 5.5.5.5/32 11 26883 3 N/A ce3 16.0.
0.20 Yes LSP_DEFAULT
B> vrf400 16 25664 Nolabel N/A vrf400 N/A
Yes LSP_DEFAULT
O> 44.44.44.44/32 12 20400 14401 N/A ce3 16.0.
0.20 Yes LSP_DEFAULT
O> 42.42.42.42/32 19 20200 3 N/A po100 15.0.
0.10 Yes LSP_DEFAULT
P> 14.14.14.14/32 15 26882 14401 N/A ce3 16.0.
0.20 Yes LSP_DEFAULT
P> 14.14.14.14/32 21 26881 18900 N/A po100 15.0.
0.10 Yes LSP_DEFAULT
O> 16.0.0.20/32 18 100500 3 N/A ce3 16.0.
0.20 Yes LSP_DEFAULT
O> 16.0.0.20/32 9 27520 3 N/A ce3 16.0.
0.20 Yes LSP_DEFAULT
O> 15.0.0.10/32 20 27521 3 N/A po100 15.0.
0.10 Yes LSP_DEFAULT
V> 12ckt:200 17 26240 Nolabel ce3 xe17.200 N/A
Yes LSP_DEFAULT
O> 15.0.0.10/32 27 100501 3 N/A po100 15.0.
0.10 Yes LSP_DEFAULT
PE1#show mpls label-space 0

```

```
Label range (min - max) : 16 - 1048575
```

```
module-static
  Default range : 16 - 14079
```

```
module-srlb
  Default range (Usable) : 14080 - 15999
  Default range (Allotted) : 14080 - 15999
```

```
module-srgb
  Default range (Usable) : 16000 - 23999
  Default range (Allotted) : 16000 - 24319
```

```
module-rsvp
  Configured range : N/A
  Current dynamic range : N/A
```

```
module-ldp
  Configured range : Not configured
  Current dynamic range : 26240 - 26879
```

```
module-bgp
  Configured range : Not configured
  Current dynamic range : 25600 - 26239
```

```
module-isis-srlb
  Configured range : N/A
  Current dynamic range : 26880 - 27519
```

```
module-ospf-srlb
  Configured range      : N/A
  Current dynamic range : 27520 - 28159

PE1#
```

P1

The following are the validation on the P1 router.

```
P10#show ip ospf neighbor detail
Neighbor 43.43.43.43, interface address 16.0.0.10
  In the area 0.0.0.0 via interface ce4
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:30
  Neighbor is detected for 00:29:51
  Neighbor is FULL for 00:29:51
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 26240
  Static adj sid: 31000
  Bidirectional Forwarding Detection is enabled

Neighbor 44.44.44.44, interface address 17.0.0.20
  In the area 0.0.0.0 via interface po400
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:37
  Neighbor is detected for 00:28:35
  Neighbor is FULL for 00:28:26
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 26241
  Static adj sid: 30700
  Bidirectional Forwarding Detection is enabled
```

As part of PE1 Validation Commands

The following are the validation on the PE1 router.

```
PE1#show segment-routing policy PE1-P3-P4-PE2
Policy-Name: PE1-P3-P4-PE2   Color 2   End-point 14.14.14.14   Tunnel-ID: 3
Admin-Status: UP   Oper-Status: UP for 2d06h40m
State Transition Count: 1
CSPF Retry Limit: 100   CSPF Retry Interval: 10
Colored Service-FTN Dependent Count: 0
Binding SID :
```

```

BSID: 27527
Alloc mode: Dynamic
Oper State: Programmed

```

```

CP ID: 1, Active
Preference: 100    Path Type: Explicit    CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 3
Segment0[LABEL]: Label :100501
Segment1[LABEL]: Label :41599
Segment1[LABEL]: Label :45900
Out-if: po100      Out-label-stack: 3/41599/45900
Computed TE Metric: 30
Attributes:
Configured:
    Explicit segment-list Name: SID_LIST_1

```

```

Last Recorded Error: Next-hop resolution failed for SID-LIST, 2d06h42m ago
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 - disabled

```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop		pri	LSP-Type		
O> 0.10	16.0.0.10/32	1	26240	3	N/A	ce4 16.0.
O> 0.10	43.43.43.43/32	3	14301	3	N/A	ce4 16.0.
O> 0.10	29.29.29.29/32	9	12901	18900	N/A	ce4 16.0.
O> 0.20	14.14.14.14/32	8	11401	11401	N/A	po400 17.0.
O> 0.10	42.42.42.42/32	10	14201	20200	N/A	ce4 16.0.
O> 0.20	44.44.44.44/32	7	14401	3	N/A	po400 17.0.
P> 0.10	43.43.43.43/32	4	25600	3	N/A	ce4 16.0.
O> 0.20	17.0.0.20/32	6	30700	3	N/A	po400 17.0.
O> 0.20	17.0.0.20/32	5	26241	3	N/A	po400 17.0.
O> 0.10	16.0.0.10/32	2	31000	3	N/A	ce4 16.0.

```

P1#show mpls label-space 0

```

```

Label range (min - max)          : 16 - 1048575

```

```

module-static
    Default range                  : 16 - 14079

```

```

module-srlb
    Default range (Usable)         : 14080 - 15999
    Default range (Allotted)       : 14080 - 15999

```

```

module-srgb
    Default range (Usable)         : 16000 - 23999
    Default range (Allotted)       : 16000 - 24319

```

```

module-rsvp
    Configured range               : N/A

```

```
Current dynamic range      : N/A

module-ldp
  Configured range         : N/A
  Current dynamic range     : N/A

module-bgp
  Configured range         : N/A
  Current dynamic range     : N/A

module-isis-srlb
  Configured range         : N/A
  Current dynamic range     : 25600 - 26239

module-ospf-srlb
  Configured range         : N/A
  Current dynamic range     : 26240 - 26879

P2
---
P2#show ip ospf neighbor detail
Neighbor 14.14.14.14, interface address 12.0.0.20
  In the area 0.0.0.0 via interface sa300
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:38
  Neighbor is detected for 00:28:44
  Neighbor is FULL for 00:28:35
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 26240
  Static adj sid: 45000
  Bidirectional Forwarding Detection is enabled

Neighbor 5.5.5.5, interface address 17.0.0.10
  In the area 0.0.0.0 via interface po400
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:31
  Neighbor is detected for 00:28:41
  Neighbor is FULL for 00:28:32
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 26241
  Static adj sid: 43000
  Bidirectional Forwarding Detection is enabled

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

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	13001	3	N/A	po400
0.10	Yes	LSP_DEFAULT				17.0.
B>	evpn:2000	3	641	Nolabel	N/A	N/A
.0.1	Yes	LSP_DEFAULT				127.0
B>	evpn:900	2	640	Nolabel	N/A	N/A
.0.1	Yes	LSP_DEFAULT				127.0
B>	evpn:900	1	16	Nolabel	N/A	N/A
.0.1	Yes	LSP_DEFAULT				127.0
O>	29.29.29.29/32	7	12901	12901	N/A	sa300
0.20	Yes	LSP_DEFAULT				12.0.
O>	14.14.14.14/32	6	11401	3	N/A	sa300
0.20	Yes	LSP_DEFAULT				12.0.
O>	12.0.0.20/32	4	26240	3	N/A	sa300
0.20	Yes	LSP_DEFAULT				12.0.
O>	43.43.43.43/32	9	14301	14301	N/A	po400
0.10	Yes	LSP_DEFAULT				17.0.
O>	42.42.42.42/32	11	14201	14201	N/A	sa300
0.20	Yes	LSP_DEFAULT				12.0.
O>	17.0.0.10/32	12	43000	3	N/A	po400
0.10	Yes	LSP_DEFAULT				17.0.
O>	17.0.0.10/32	5	26241	3	N/A	po400
0.10	Yes	LSP_DEFAULT				17.0.
O>	12.0.0.20/32	10	45000	3	N/A	sa300
0.20	Yes	LSP_DEFAULT				12.0.

P2#show mpls label-space 0

Label range (min - max) : 16 - 1048575

module-static

Default range : 16 - 14079

module-srlb

Default range : 14080 - 15999

Configured range : 41000 - 50000

module-srgb

Default range : 16000 - 23999

Configured range : 10001 - 20000

module-rsvp

Configured range : N/A

Current dynamic range : N/A

module-ldp

Configured range : N/A

Current dynamic range : N/A

module-bgp

Configured range : Not configured

Current dynamic range : 25600 - 26239

module-ospf-srlb

Configured range : N/A

Current dynamic range : 26240 - 26879

P2#!

P2

The following are the validation on the P2 router.

```
P2#show ip ospf neighbor detail
Neighbor 14.14.14.14, interface address 12.0.0.20
  In the area 0.0.0.0 via interface sa300
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:38
  Neighbor is detected for 00:28:44
  Neighbor is FULL for 00:28:35
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 26240
  Static adj sid: 45000
  Bidirectional Forwarding Detection is enabled

Neighbor 5.5.5.5, interface address 17.0.0.10
  In the area 0.0.0.0 via interface po400
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:31
  Neighbor is detected for 00:28:41
  Neighbor is FULL for 00:28:32
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 26241
  Static adj sid: 43000
  Bidirectional Forwarding Detection is enabled

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

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       13001      3         N/A      po400      17.0.
0.10      Yes      LSP_DEFAULT
B>  evpn:2000       3       641       Nolabel    N/A      N/A        127.0
.0.1      Yes      LSP_DEFAULT
B>  evpn:900        2       640       Nolabel    N/A      N/A        127.0
.0.1      Yes      LSP_DEFAULT
B>  evpn:900        1       16        Nolabel    N/A      N/A        127.0
.0.1      Yes      LSP_DEFAULT
O>  29.29.29.29/32  7       12901     12901     N/A      sa300      12.0.
0.20      Yes      LSP_DEFAULT
O>  14.14.14.14/32  6       11401     3         N/A      sa300      12.0.
0.20      Yes      LSP_DEFAULT
```

```

O> 12.0.0.20/32      4      26240      3      N/A      sa300      12.0.
0.20      Yes      LSP_DEFAULT
O> 43.43.43.43/32    9      14301      14301      N/A      po400      17.0.
0.10      Yes      LSP_DEFAULT
O> 42.42.42.42/32    11     14201      14201      N/A      sa300      12.0.
0.20      Yes      LSP_DEFAULT
O> 17.0.0.10/32      12     43000      3      N/A      po400      17.0.
0.10      Yes      LSP_DEFAULT
O> 17.0.0.10/32      5      26241      3      N/A      po400      17.0.
0.10      Yes      LSP_DEFAULT
O> 12.0.0.20/32      10     45000      3      N/A      sa300      12.0.
0.20      Yes      LSP_DEFAULT
P2#show mpls label-space 0

Label range (min - max)      : 16 - 1048575

module-static
  Default range              : 16 - 14079

module-srlb
  Default range              : 14080 - 15999
  Configured range           : 41000 - 50000

module-srgb
  Default range              : 16000 - 23999
  Configured range           : 10001 - 20000

module-rsvp
  Configured range           : N/A
  Current dynamic range      : N/A

module-ldp
  Configured range           : N/A
  Current dynamic range      : N/A

module-bgp
  Configured range           : Not configured
  Current dynamic range      : 25600 - 26239

module-ospf-srlb
  Configured range           : N/A
  Current dynamic range      : 26240 - 26879

P2#!

```

P3

The following are the validation on the P3 router.

```

P2#show ip ospf neighbor detail
Neighbor 29.29.29.29, interface address 14.0.0.20
  In the area 0.0.0.0 via interface xe9
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|0|-|-|-|E|-)
  Dead timer due in 00:00:39
  Neighbor is detected for 00:22:20
  Neighbor is FULL for 00:22:20
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on

```

```

Thread Database Description Retransmission off
Thread Link State Request Retransmission off
Thread Link State Update Retransmission off
System assigned adj sid: 25601
Static adj sid: 41599
Bidirectional Forwarding Detection is enabled

Neighbor 43.43.43.43, interface address 15.0.0.20
In the area 0.0.0.0 via interface po100
Neighbor priority is 1, State is Full, 5 state changes
DR is 0.0.0.0, BDR is 0.0.0.0
Options is 0x42 (-|O|-|-|-|E|-)
Dead timer due in 00:00:37
Neighbor is detected for 00:22:27
Neighbor is FULL for 00:22:17
Database Summary List 0
Link State Request List 0
Link State Retransmission List 0
Crypt Sequence Number is 0
Thread Inactivity Timer on
Thread Database Description Retransmission off
Thread Link State Request Retransmission off
Thread Link State Update Retransmission off
System assigned adj sid: 25600
Static adj sid: 45159
Bidirectional Forwarding Detection is enabled

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

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      2        19000      19000      N/A       po100      15.0.
0.20      Yes      LSP_DEFAULT
O> 29.29.29.29/32  4        18900      3          N/A       xe9        14.0.
0.20      Yes      LSP_DEFAULT
O> 14.14.14.14/32  3        17400      11401      N/A       xe9        14.0.
0.20      Yes      LSP_DEFAULT
O> 14.0.0.20/32    1        25601      3          N/A       xe9        14.0.
0.20      Yes      LSP_DEFAULT
O> 44.44.44.44/32  6        20400      14401      N/A       xe9        14.0.
0.20      Yes      LSP_DEFAULT
O> 43.43.43.43/32  5        20300      3          N/A       po100      15.0.
0.20      Yes      LSP_DEFAULT
O> 15.0.0.20/32    7        25600      3          N/A       po100      15.0.
0.20      Yes      LSP_DEFAULT
O> 14.0.0.20/32    8        41599      3          N/A       xe9        14.0.
0.20      Yes      LSP_DEFAULT
O> 15.0.0.20/32    9        45159      3          N/A       po100      15.0.
0.20      Yes      LSP_DEFAULT
P3#show mpls label-space 0

Label range (min - max)          : 16 - 1048575

module-static
  Default range                  : 16 - 14079

module-srlb
  Default range (Usable)         : 14080 - 15999
  Default range (Allotted)       : 14080 - 15999

module-srgb

```



```

Default range (Usable)      : 16000 - 23999
Default range (Allotted)    : 16000 - 24319

module-rsvp
  Configured range          : N/A
  Current dynamic range     : N/A

module-ldp
  Configured range          : N/A
  Current dynamic range     : N/A

module-bgp
  Configured range          : N/A
  Current dynamic range     : N/A

module-ospf-srlb
  Configured range          : N/A
  Current dynamic range     : 25600 - 26239

P3#!

```

P4

The following are the validation on the P4 router.

```

P4#show ip ospf neighbor detail
Neighbor 14.14.14.14, interface address 13.0.0.10
  In the area 0.0.0.0 via interface xe2.2000
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:35
  Neighbor is detected for 00:33:03
  Neighbor is FULL for 00:32:55
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 26240
  Static adj sid: 45900
  Bidirectional Forwarding Detection is enabled

Neighbor 42.42.42.42, interface address 14.0.0.10
  In the area 0.0.0.0 via interface xe9
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:34
  Neighbor is detected for 00:22:33
  Neighbor is FULL for 00:22:23
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off

```

```

Thread Link State Update Retransmission off
System assigned adj sid: 26241
Static adj sid: 46000
Bidirectional Forwarding Detection is enabled

```

P4#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>	44.44.44.44/32	7	14401	14401	N/A	xe2.2000 13.0.
0.10	Yes	LSP_DEFAULT				
O>	14.14.14.14/32	5	11401	3	N/A	xe2.2000 13.0.
0.10	Yes	LSP_DEFAULT				
B>	evpn:900	2	640	Nolabel	N/A	N/A 127.0
.0.1	Yes	LSP_DEFAULT				
B>	evpn:900	1	16	Nolabel	N/A	N/A 127.0
.0.1	Yes	LSP_DEFAULT				
B>	evpn:2000	3	641	Nolabel	N/A	N/A 127.0
.0.1	Yes	LSP_DEFAULT				
O>	42.42.42.42/32	12	14201	3	N/A	xe9 14.0.
0.10	Yes	LSP_DEFAULT				
O>	5.5.5.5/32	8	13001	13001	N/A	xe2.2000 13.0.
0.10	Yes	LSP_DEFAULT				
O>	43.43.43.43/32	9	14301	20300	N/A	xe9 14.0.
0.10	Yes	LSP_DEFAULT				
O>	13.0.0.10/32	6	45900	3	N/A	xe2.2000 13.0.
0.10	Yes	LSP_DEFAULT				
O>	13.0.0.10/32	4	26240	3	N/A	xe2.2000 13.0.
0.10	Yes	LSP_DEFAULT				
O>	14.0.0.10/32	10	26241	3	N/A	xe9 14.0.
0.10	Yes	LSP_DEFAULT				
O>	14.0.0.10/32	11	46000	3	N/A	xe9 14.0.
0.10	Yes	LSP_DEFAULT				

P4#show mpls label-space 0

```

Label range (min - max)      : 16 - 1048575

module-static
  Default range              : 16 - 14079

module-srlb
  Default range              : 14080 - 15999
  Configured range          : 41000 - 50000

module-srgb
  Default range              : 16000 - 23999
  Configured range          : 10001 - 20000

module-rsvp
  Configured range           : N/A
  Current dynamic range      : N/A

module-ldp
  Configured range           : N/A
  Current dynamic range      : N/A

module-bgp
  Configured range           : Not configured
  Current dynamic range      : 25600 - 26239

```

```

module-ospf-srlb
  Configured range      : N/A
  Current dynamic range : 26240 - 26879

P4#!

```

PE2

The following are the validation on the PE2 router.

```

PE2#show ip ospf neighbor detail
Neighbor 44.44.44.44, interface address 12.0.0.10
  In the area 0.0.0.0 via interface sa300
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:39
  Neighbor is detected for 00:28:45
  Neighbor is FULL for 00:28:45
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 27521
  Static adj sid: 70000
  Bidirectional Forwarding Detection is enabled

Neighbor 29.29.29.29, interface address 13.0.0.20
  In the area 0.0.0.0 via interface xe2.2000
  Neighbor priority is 1, State is Full, 5 state changes
  DR is 0.0.0.0, BDR is 0.0.0.0
  Options is 0x42 (-|O|-|-|-|E|-)
  Dead timer due in 00:00:37
  Neighbor is detected for 00:32:58
  Neighbor is FULL for 00:32:58
  Database Summary List 0
  Link State Request List 0
  Link State Retransmission List 0
  Crypt Sequence Number is 0
  Thread Inactivity Timer on
  Thread Database Description Retransmission off
  Thread Link State Request Retransmission off
  Thread Link State Update Retransmission off
  System assigned adj sid: 27520
  Static adj sid: 70001
  Bidirectional Forwarding Detection is enabled

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>    29.29.29.29/32    7      12901      3          N/A       xe2.2000    13.0.
0.20    Yes      LSP_DEFAULT
B>    evpn:600        2      640       Nolabel    N/A       N/A        127.0

```

```

.0.1      Yes  LSP_DEFAULT
B> evpn:600      3      17      Nolabel      N/A      N/A      127.0
.0.1      Yes  LSP_DEFAULT
B> evpn:252      1      16      Nolabel      N/A      N/A      127.0
.0.1      Yes  LSP_DEFAULT
B> evpn:700      5      18      Nolabel      N/A      N/A      127.0
.0.1      Yes  LSP_DEFAULT
B> evpn:700      4      641     Nolabel      N/A      N/A      127.0
.0.1      Yes  LSP_DEFAULT
O> 13.0.0.20/32  6      27520     3      N/A      xe2.2000     13.0.
0.20      Yes  LSP_DEFAULT
O> 44.44.44.44/32 9      14401     3      N/A      sa300        12.0.
0.10      Yes  LSP_DEFAULT
O> 42.42.42.42/32 17     14201     14201     N/A      xe2.2000     13.0.
0.20      Yes  LSP_DEFAULT
O> 5.5.5.5/32    10     13001     13001     N/A      sa300        12.0.
0.10      Yes  LSP_DEFAULT
O> 43.43.43.43/32 11     14301     14301     N/A      sa300        12.0.
0.10      Yes  LSP_DEFAULT
P> 43.43.43.43/32 18     26881     14201     N/A      xe2.2000     13.0.
0.20      Yes  LSP_DEFAULT
B> vrf400        12     25664     Nolabel     N/A      vrf400       N/A
          Yes  LSP_DEFAULT
P> 43.43.43.43/32 13     26882     13001     N/A      sa300        12.0.
0.10      Yes  LSP_DEFAULT
O> 12.0.0.10/32  15     70000     3      N/A      sa300        12.0.
0.10      Yes  LSP_DEFAULT
O> 12.0.0.10/32  8      27521     3      N/A      sa300        12.0.
0.10      Yes  LSP_DEFAULT
V> 12ckt:200     14     26240     Nolabel     sa300      xe17.200     N/A
          Yes  LSP_DEFAULT
O> 13.0.0.20/32  16     70001     3      N/A      xe2.2000     13.0.
0.20      Yes  LSP_DEFAULT
PE2#show mpls label-space 0
Label range (min - max)      : 16 - 1048575

Label range (min - max)      : 16 - 1048575

module-static
  Default range               : 16 - 14079

module-srlb
  Default range (Usable)      : 14080 - 15999
  Default range (Allotted)    : 14080 - 15999

module-srgb
  Default range (Usable)      : 16000 - 23999
  Default range (Allotted)    : 16000 - 24319

module-rsvp
  Configured range            : N/A
  Current dynamic range       : N/A

+ module-ldp
  Configured range            : Not configured
  Current dynamic range       : 26240 - 26879

module-bgp
  Configured range            : Not configured
  Current dynamic range       : 25600 - 26239

module-isis-srlb
  Configured range            : N/A
  Current dynamic range       : 26880 - 27519

module-ospf-srlb
  Configured range            : N/A
  Current dynamic range       : 27520 - 28159

```

ISIS Configuration

Configure IS-IS with Segment Routing, assign user-defined Adj-SIDs to specific interfaces, and set up SR-TE tunnels from PE1 (headend) to PE2 (tailend) to enable deterministic traffic engineering across the core network.

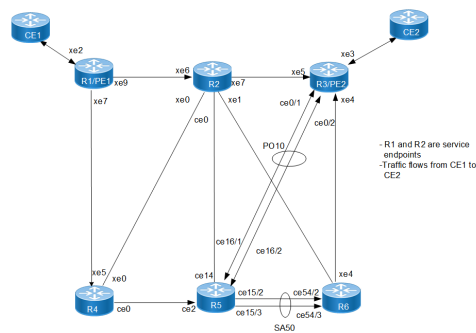
Topology

This topology illustrates Segment Routing with IS-IS using Adjacency SIDs for precise traffic engineering. R1 (PE1) and R3 (PE2) are service endpoints, with traffic flowing from CE1 to CE2.

R1 connects to R2 and R4, while R3 connects to R2, R5, and CE2. R2, R4, R5, and R6 form the SR-MPLS core, enabling multiple path options. R5 plays a central role, connecting with all core routers, including an aggregated link (Port-Channel 10) to R2.

Adjacency SIDs are assigned to point-to-point links like R1–R2, R2–R3, and R5–R3. These locally significant SIDs allow traffic to be explicitly routed through specific links. For example, traffic from CE1 to CE2 can be steered via R1 → R2 → R5 → R3 using a mix of Node and Adj-SIDs, bypassing shortest-path routing.

Figure 22. L2VPN with SRLB-SID-ADJ Configuration Topology



The following steps describe to configure user-defined adjacency SIDs in an IS-IS-SR environment for deterministic traffic engineering.

- Define the Segment Routing Local Block (SRLB) as the local SID range (42000–47000) for index-based static SID allocation.

```
#configure terminal

(config)#segment-routing

(config-sr)#local block 42000 47000
```

- Assign a user-defined adjacency SID on an interface using either an absolute SID or an index-based method. Absolute assignment sets a fixed SID value explicitly, while index-based assignment calculates the SID by adding the index to the SRLB base.

- Absolute SID:** Directly configure a fixed SID on the interface. For example, adjacency-sid isis absolute 42151 assigns SID 42151 to interface xe9, suitable for centrally managed environments.

```
(config)# interface xe9
(config-if)#adjacency-sid isis absolute 42151
```

- Index-Based SID:** Configure an index value that, when added to the SRLB base, forms the SID. For instance, adjacency-sid isis index 14 on interface xe7. 101 results in SID 42014 assuming an SRLB base of 42000.

```
(config)# interface xe7.101

(config-if)# adjacency-sid isis index 14
```

Configuration Snapshot

R1

The following are the configuration snapshot on the R1 router.

```
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
admin-group blue 1
!
tunnel-policy TP1
  color 61
!
tunnel-policy TP2
  color 102
!
!
ip vrf management
!
ip vrf VPN101
  tunnel-select-policy TP1
  rd 70000:100
  route-target both 100:100
!
segment-routing
  local block 42000 47000
  traffic-engineering
    segment-list SID_LIST_BSID_1
      index 1 segment-type-1 42151
      index 2 segment-type-1 26024
      index 3 segment-type-1 70045
      index 4 segment-type-1 555
    exit-sr-sl
  !
  policy T123
    color 101 end-point 3.3.3.3
    candidate-path 1
      dynamic-path isis 1
      constraints
        10.10.12.2 strict
        10.10.23.3 strict
    exit-cp-cons
  !
  exit-pol-cp
  !
  exit-sr-pol
  !
  policy T1245_bsid_563
    color 61 end-point 3.3.3.3
    candidate-path 1
      explicit segment-list SID_LIST_BSID_1
    exit-pol-cp
  !
  candidate-path 2
    preference 80
    dynamic-path isis 1
    constraints
```

```
    affinity include-all blue
    exit-cp-cons
    !
    exit-pol-cp
    !
    exit-sr-pol
    !
s-bfd sr policy T1245_bsid_563
!
s-bfd discriminator 1.1.1.1
!
interface lo
    ip address 127.0.0.1/8
    ip address 1.1.1.1/32 secondary
    ipv6 address ::1/128
    prefix-sid index 101 no-php
    ip router isis 1
    !
interface xe2
    speed 10g
    mtu 9216
    !
interface xe2.101
    encapsulation dot1q 101
    load-interval 30
    ip vrf forwarding VPN101
    ip address 100.7.1.1/24
    ipv6 address 101::1/64
    mtu 9216
    !
interface xe7
    speed 10g
    mtu 9216
    !
interface xe7.101
    encapsulation dot1q 14
    ip address 10.10.14.1/24
    label-switching
    admin-group blue
    adjacency-sid isis index 14
    ip ospf network point-to-point
    isis network point-to-point
    ip router isis 1
    enable-ldp ipv4
    !
interface xe9
    speed 10g
    load-interval 30
    ip address 10.10.12.1/24
    mtu 9216
    label-switching
    extended-admin-group blue
    adjacency-sid isis absolute 42151
    ip ospf network point-to-point
    isis network point-to-point
    ip router isis 1
    !
router isis 1
    is-type level-2-only
    metric-style wide
    mpls traffic-eng router-id 1.1.1.1
    mpls traffic-eng level-2
    capability cspf
    dynamic-hostname
    fast-reroute ti-lfa level-1 proto ipv4
    fast-reroute ti-lfa level-2 proto ipv4
    bfd all-interfaces
    net 49.0001.0000.0000.0001.00
```

```
passive-interface lo
isis segment-routing global block 16000 19000
segment-routing mpls
!
router bgp 70000
  bgp router-id 1.1.1.1
  neighbor 3.3.3.3 remote-as 70000
  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 VPN101
  redistribute connected
  neighbor 100.7.1.2 remote-as 200
  neighbor 100.7.1.2 activate
  exit-address-family
  !
  address-family ipv6 vrf VPN101
  redistribute connected
  neighbor 101::2 remote-as 200
  neighbor 101::2 activate
  exit-address-family
  !
exit
!
end
```

R2

The following are the configuration snapshot on the R2 router.

```
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
hostname R2
!
ip vrf management
!
segment-routing
  local block 26000 30000
!
interface ce0
  load-interval 30
  ip address 10.10.25.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
!
interface lo
  ip address 127.0.0.1/8
  ip address 2.2.2.2/32 secondary
  ipv6 address ::1/128
  prefix-sid index 201 no-php
  ip router isis 1
!
```



```
interface xe0
  load-interval 30
  ip address 10.10.24.2/24
  mtu 9216
  label-switching
  adjacency-sid isis index 24
  isis network point-to-point
  ip router isis 1
!
interface xe1
  ip address 10.10.26.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
!
interface xe6
  load-interval 30
  ip address 10.10.12.2/24
  ip address 10.10.21.2/24 secondary
  ip address 10.10.31.2/24 secondary
  mtu 9216
  label-switching
  adjacency-sid isis index 21
  isis network point-to-point
  ip router isis 1
!
interface xe7
  load-interval 30
  ip address 10.10.23.2/24
  mtu 9216
  label-switching
  adjacency-sid isis index 222
  adjacency-sid ospf absolute 26022
  isis network point-to-point
  ip router isis 1
!
router isis 1
  is-type level-2-only
  metric-style wide
  mpls traffic-eng router-id 2.2.2.2
  mpls traffic-eng level-2
  capability cspf
  dynamic-hostname
  fast-reroute ti-lfa level-1 proto ipv4
  fast-reroute ti-lfa level-2 proto ipv4
  bfd all-interfaces
  net 49.0001.0000.0000.0022.00
  passive-interface lo
  isis segment-routing global block 16000 19000
  segment-routing entropy-label
  segment-routing mpls
!
end
```

R3

The following are the configuration snapshot on the R3 router.

```
!
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
```

```
!  
hostname R3  
port ce0 breakout 4X10g  
!  
tunnel-policy TP1  
  color 101  
!  
ip vrf VPN101  
  tunnel-select-policy TP1  
  rd 70000:100  
  route-target both 100:100  
!  
segment-routing  
  local block 30000 35000  
  traffic-engineering  
    policy T321  
    color 101 end-point 1.1.1.1  
    candidate-path 1  
    dynamic-path isis 1  
    constraints  
      10.10.23.2 strict  
      10.10.12.1 strict  
    exit-cp-cons  
    !  
    exit-pol-cp  
    !  
    exit-sr-pol  
    !  
    exit-te  
    !  
  s-bfd sr policy T321  
  !  
  s-bfd discriminator 3.3.3.3  
  !  
  !  
interface po10  
  load-interval 30  
  ip address 10.10.35.3/24  
  mtu 9216  
  label-switching  
  adjacency-sid isis index 35  
  isis network point-to-point  
  ip router isis 1  
!  
interface sa1  
!  
interface ce0/1  
  channel-group 10 mode active  
!  
interface ce0/2  
  channel-group 10 mode active  
!  
interface lo  
  ip address 127.0.0.1/8  
  ip address 3.3.3.3/32 secondary  
  ipv6 address ::1/128  
  prefix-sid index 301 no-php  
  ip router isis 1  
!  
interface xe3  
  speed 10g  
!  
interface xe3.101  
  encapsulation dot1q 101  
  load-interval 30  
  ip vrf forwarding VPN101  
  ip address 100.8.1.1/24  
  ipv6 address 201::1/64
```

```
!  
interface xe4  
  speed 10g  
  load-interval 30  
  ip address 10.10.36.3/24  
  mtu 9216  
  label-switching  
  isis network point-to-point  
  ip router isis 1  
!  
interface xe5  
  speed 10g  
  load-interval 30  
  ip address 10.10.23.3/24  
  mtu 9216  
  label-switching  
  adjacency-sid isis index 32  
  ip ospf network point-to-point  
  isis network point-to-point  
  ip router isis 1  
!  
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  
  dynamic-hostname  
  fast-reroute ti-lfa level-1 proto ipv4  
  fast-reroute ti-lfa level-2 proto ipv4  
  bfd all-interfaces  
  net 49.0001.0000.0000.0002.00  
  passive-interface lo  
  isis segment-routing global block 16000 19000  
  segment-routing mpls  
!  
router bgp 70000  
  bgp router-id 3.3.3.3  
  neighbor 1.1.1.1 remote-as 70000  
  neighbor 1.1.1.1 update-source lo  
  neighbor 3001::2 remote-as 400  
  !  
  address-family vpnv4 unicast  
  neighbor 1.1.1.1 activate  
  exit-address-family  
  !  
  address-family vpnv6 unicast  
  neighbor 1.1.1.1 activate  
  exit-address-family  
  !  
  address-family ipv4 vrf VPN101  
  redistribute connected  
  neighbor 100.8.1.2 remote-as 100  
  neighbor 100.8.1.2 activate  
  exit-address-family  
  !  
  address-family ipv6 vrf VPN101  
  redistribute connected  
  neighbor 201::2 remote-as 100  
  neighbor 201::2 activate  
  exit-address-family  
  !  
exit  
!  
end
```

R4

The following are the configuration snapshot on the R4 router.

```
!  
qos enable  
!  
mpls ilm-ecmp sr  
mpls ftn-ecmp sr  
!  
hostname R4  
admin-group blue 1  
!  
segment-routing  
  global block 65000 69000  
  local block 70000 75000  
!  
interface ce0  
  speed 40g  
  ip address 10.10.45.4/24  
  mtu 9216  
  label-switching  
  admin-group blue  
  adjacency-sid isis index 45  
  ip ospf network point-to-point  
  isis network point-to-point  
  ip router isis 1  
  isis wide-metric 5  
!  
interface lo  
  ip address 127.0.0.1/8  
  ip address 4.4.4.4/32 secondary  
  ipv6 address ::1/128  
  prefix-sid index 401 no-php  
  ip router isis 1  
!  
interface xe0  
  load-interval 30  
  ip address 10.10.24.4/24  
  mtu 9216  
  label-switching  
  adjacency-sid isis index 42  
  isis network point-to-point  
  ip router isis 1  
!  
interface xe5  
!  
interface xe5.101  
  encapsulation dot1q 14  
  ip address 10.10.14.4/24  
  label-switching  
  adjacency-sid isis absolute 72101  
  ip ospf network point-to-point  
  isis network point-to-point  
  ip router isis 1  
!  
router isis 1  
  is-type level-2-only  
  metric-style wide  
  mpls traffic-eng router-id 4.4.4.4  
  mpls traffic-eng level-2  
  capability cspf  
  dynamic-hostname  
  fast-reroute ti-lfa level-1 proto ipv4  
  fast-reroute ti-lfa level-2 proto ipv4  
  bfd all-interfaces  
  net 49.0001.0000.0000.0044.00
```

```
passive-interface lo
isis segment-routing global block 65000 65800
segment-routing entropy-label
segment-routing mpls
!
end
```

R5

The following are the configuration snapshot on the R5 router.

```
!
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
hostname R5
port cel5 breakout 4X10g
port cel6 breakout 4X10g
admin-group blue 1
!
segment-routing
  local block 40000 48000
!
interface po10
  load-interval 30
  ip address 10.10.35.5/24
  mtu 9216
  label-switching
  admin-group blue
  adjacency-sid isis absolute 40124
  isis network point-to-point
  ip router isis 1
!
interface sa1
!
interface sa50
  load-interval 30
  ip address 10.10.65.5/24
  mtu 9216
  label-switching
  adjacency-sid isis index 110
  ip ospf network point-to-point
  isis network point-to-point
  ip router isis 1
  isis wide-metric 5
!
interface ce0
!
interface cel
!
interface ce2
  speed 40g
  load-interval 30
  ip address 10.10.45.5/24
  mtu 9216
  label-switching
  adjacency-sid isis index 54
  ip ospf network point-to-point
  isis network point-to-point
  ip router isis 1
!
interface cel4
```

```
load-interval 30
ip address 10.10.25.5/24
mtu 9216
label-switching
adjacency-sid isis index 52
isis network point-to-point
ip router isis 1
!
interface cel5/1
ip address 10.10.56.5/24
mtu 9216
label-switching
admin-group blue
adjacency-sid isis index 56
shutdown
isis network point-to-point
ip router isis 1
!
interface cel5/2
static-channel-group 50
!
interface cel5/3
static-channel-group 50
!
interface cel5/4
ip address 10.56.56.5/24
mtu 9216
label-switching
admin-group blue
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis wide-metric 5
!
interface cel6/1
channel-group 10 mode active
!
interface cel6/2
channel-group 10 mode active
!
interface cel6/3
!
interface cel6/4
!
interface lo
ip address 127.0.0.1/8
ip address 5.5.5.5/32 secondary
ipv6 address ::1/128
prefix-sid index 501 no-php
ip router isis 1
!
exit
!
router isis 1
is-type level-1-2
metric-style wide
mpls traffic-eng router-id 5.5.5.5
mpls traffic-eng level-1
mpls traffic-eng level-2
capability cspf
dynamic-hostname
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0001.0000.0000.0055.00
redistribute isis level-2 into level-1
passive-interface lo
isis segment-routing global block 16000 19000
```

```
segment-routing entropy-label
segment-routing mpls
!
end
```

R6

The following are the configuration snapshot on the R6 router.

```
!
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
hostname R6
port ce54 breakout 4X10g
admin-group blue 1
!
segment-routing
local block 30000 35000
!
interface sa50
load-interval 30
ip address 10.10.65.6/24
mtu 9216
label-switching
adjacency-sid isis absolute 30010
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
!
interface ce54/1
ip address 10.10.56.6/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
!
interface ce54/2
static-channel-group 50
!
interface ce54/3
static-channel-group 50
!
interface ce54/4
ip address 10.56.56.6/24
mtu 9216
label-switching
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
!
interface lo
ip address 127.0.0.1/8
ip address 6.6.6.6/32 secondary
ipv6 address ::1/128
prefix-sid index 601 no-php
ip router isis 1
!
interface xe2
ip address 10.10.26.6/24
mtu 9216
label-switching
```

```

isis network point-to-point
ip router isis 1
!
interface xe4
ip address 10.10.36.6/24
mtu 9216
label-switching
admin-group blue
adjacency-sid isis absolute 35000
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
!
router isis 1
is-type level-1-only
metric-style wide
mpls traffic-eng router-id 6.6.6.6
mpls traffic-eng level-2
dynamic-hostname
fast-reroute ti-lfa level-1 proto ipv4
bfd all-interfaces
net 49.0001.0000.0000.0066.00
passive-interface lo
isis segment-routing global block 16000 19000
segment-routing entropy-label
segment-routing mpls
!
end

```

Validation

To verify the configured adjacency SIDs and their advertisement status.

```
PE1#show clns neighbors xe9 detail
```

```

Tag 1: VRF : default
System Id      Interface  SNPA                State Holdtime  Type Protocol
R2             xe9         80a2.355b.7008      Up      24          L2   IS-IS
Adjacency ID: 1
Uptime: 1d01h53m
Area Address(es): 49.0001
IP Address(es): 10.10.12.2 10.10.21.2 10.10.31.2
Level-2 Protocols Supported: IPv4
IPv4 Bidirectional Forwarding Detection is enabled
Adjacency advertisement: Advertise
Adjacency SID: 28161, ILM ID: 18
Static Adjacency SID: 42151, ILM ID: 19
Bypass trunk ID: 2201,
PQ-router ID: 4.4.4.4

```

```
PE1#show mpls ilm-table 10.10.12.2/32
```

```

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, UPStr - upstream

```

```
ILM-ECMP LDP: Disabled, SR: Enabled
```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop		pri	Algo-Num	UpTime	UPStr peers
i>	10.10.12.2/32	18	28161	3	N/A	xe9 10.10
.12.2	Yes 0		1d01h53m	28161	65201	N/A xe7.101 10.10
.14.4	No -	-	-			


```

i> 10.10.12.2/32 19 42151 3 N/A xe9 10.10
.12.2 Yes 0 1d01h53m
42151 65201 N/A xe7.101 10.10
.14.4 No - -

PE1#show isis database verbose PE1.00-00
Tag 1: VRF : default
IS-IS Level-2 Link State Database:
LSPID LSP Seq Num LSP Checksum LSP Holdtime ATT/P/OL
R1.00-00 * 0x00000006D 0x587B 681 0/0/0
Area Address: 49.0001
NLPID: 0xCC
Hostname: R1
IP Address: 10.10.14.1
Router ID: 1.1.1.1
Router Cap: 1.1.1.1
Maximum SID Depth:
Entropy Readable Label Depth : 10
SRGB Range: 3001 SRGB Base SID: 16000 I:1 V:0
SR-Algorithms:
Algorithm: SPF
SBFD Discriminator: 1.1.1.1
Metric: 10 IS-Extended R4.00
Admin-Group:
Group 1
IPv4 Interface Address: 10.10.14.1
Neighbor IP Address: 10.10.14.4
Maximum Link Bandwidth : 10000000.00 kbits/sec
Reservable Bandwidth : 10000000.00 kbits/sec
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 1: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 2: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 3: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 4: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 5: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 6: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 7: 10000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 28160 F:0 B:0 V:1 L:1 S:0 P:0
Adjacency SID: 42014 F:0 B:0 V:1 L:1 S:0 P:1
Metric: 10 IS-Extended R2.00
IPv4 Interface Address: 10.10.12.1
Neighbor IP Address: 10.10.12.2
Maximum Link Bandwidth : 10000000.00 kbits/sec
Reservable Bandwidth : 10000000.00 kbits/sec
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 1: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 2: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 3: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 4: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 5: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 6: 10000000.00 kbits/sec
Unreserved Bandwidth at priority 7: 10000000.00 kbits/sec
TE-Default Metric: 10
Extended Administrative Group Bits (96):
(35)
Adjacency SID: 28161 F:0 B:0 V:1 L:1 S:0 P:0
Adjacency SID: 42151 F:0 B:0 V:1 L:1 S:0 P:1
Metric: 0 IP-Extended 1.1.1.1/32
Prefix-SID: index 101, Algorithm: SPF, R:0 N:1 P:1 E:0 V:0 L:0
Prefix Attribute Flags[0]: ELC Set
Metric: 10 IP-Extended 10.10.14.0/24
Prefix Attribute Flags[0]: ELC Set
Metric: 10 IP-Extended 10.10.12.0/24
Prefix Attribute Flags[0]: ELC Set

```

```
PE1#show isis segment-routing capability
```

```
Tag 1 Segment-Routing:
```

```
-----
Advertisement Router Capability :1.1.1.1
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :10
SID Range List Count           :1
SID's Range                    :16000 - 19000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :2.2.2.2
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :16000 - 19000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :3.3.3.3
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :10
SID Range List Count           :1
SID's Range                    :16000 - 19000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :4.4.4.4
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :801
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :65000 - 65800
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :5.5.5.5
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :10
SID Range List Count           :1
SID's Range                    :16000 - 19000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :6.6.6.6
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :16000 - 19000
Total SID's Supported (SRLB)   :0
SRLB Range List Count          :0
```

```
PE1#show segment-routing policy T123
```

```
Policy-Name: T123    Color 101    End-point 3.3.3.3    Tunnel-ID: 2
```

```
Admin-Status: UP      Oper-Status: UP for 03:41:23
State Transition Count: 11
CSPF Retry Limit: 100   CSPF Retry Interval: 10
Colored Service-FTN Dependent Count: 0
Binding SID :
BSID: 27526
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 100      Path Type: Dynamic(isis)      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :42151
Segment1[LABEL]: Label :26222
Out-if: xe9          Out-label-stack: 3/26222
Computed TE Metric: 20
Attributes:
  Configured:
    SID-Algorithm: 0
    Affinity:
    Metric-type: TE
    IP Constraints: 10.10.12.2 strict
                  10.10.23.3 strict

Last Recorded Error: Route Not Found, 03:41:34 ago
```

Implementation Example

Explicit Path Control in SR-TE Policies.

In an SR-MPLS environment, controllers (like an SDN orchestrator or PCE) require deterministic SIDs to build and enforce SR-TE paths. User-defined Adjacency SIDs ensure the SID values assigned to specific links are predictable and persistent, enabling the controller to push exact path instructions across the network.

Limitations

- Supports only Point-to-Point (P2P) adjacencies. LAN or broadcast interfaces are not supported. In other words, manual-adj-sid is supported only on P2P interfaces.
- For dynamic SR policies, changes to link (transit) attributes-such as affinity, adj-SID, or metric-do not automatically trigger a re-computation of the SR policy's Explicit Route Object (ERO). To apply such changes, you must manually reset the SR policy's administrative state by setting it to admin-state down and then to no admin-state down.
- If a dynamic SR policy includes a constraint based on link attributes (such as affinity or link-IP), it uses either a manual-adj-sid or a dynamic-adj-sid, even if both are present. There is no preference between manual and dynamic adj-SIDs in this case.

Segment Routing Policy for Traffic Engineering

Segment routing allows a headend node to steer a packet flow along any desired path. Intermediate per-flow states are eliminated due to source routing. The headend node is said to steer a flow into a segment routing policy. The header of a packet steered in an segment routing policy is augmented with the ordered list of segments associated with that segment routing policy.

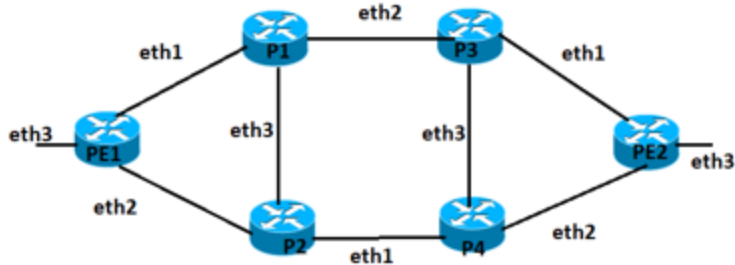
The path of a segment routing policy is an ordered list of segments and can be an explicit path or a dynamic path:

- For a dynamic candidate-path, the head-end computes the ordered list of segments based on certain user-specified optimization objectives and set of constraints.
- For an explicit candidate-path, the ordered list of segments can be explicitly specified by the operator directly via commands or PCEP controller.

This section shows how to configure a segment routing policy for traffic engineering using dynamic paths and explicit paths.

Topology

Figure 23. Segment routing topology for traffic engineering



Notes:

- You must ensure that prefix SIDs are unique globally.
- By default, the CSPF retry limit is 100 times and the CSPF retry interval is 10 seconds. If a policy does not come up within 1000 seconds, it will require operator intervention.

Dynamic Path Policy with ISIS Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

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 the IP address of the interface.
PE1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#prefix-sid index 1	Configure prefix sid index value.

PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.
PE1(config-if)#ip address 10.1.2.1/24	Configure the IP address of the interface.
PE1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config)#exit	Exit interface mode
PE1(config)#interface eth2	Enter interface mode.
PE1(config-if)#ip address 10.1.6.1/24	Configure the IP address of the interface.
PE1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router isis 1	Set the routing process ID.
PE1(config-router)#metric-style wide	Configure metric style as wide.
PE1(Config)#commit	Commit candidate configuration to be running configuration
PE1(config-router)#is-type level-1	Configure is-type.
PE1(config-router)#net 49.0001.0000.0000.0011.00	Configure network entity title (NET).
PE1(config-router)#mpls traffic-eng router-id 1.1.1.1	Enable MPLS Traffic Engineering under router process.
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE1(config-router)#capability cspf	Enable cspf capability under ISIS 1 process.
PE1(config-router)#segment-routing mpls	Enable segment routing under router process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#segment-routing	Configuring segment-routing
PE1(config-sr)#traffic-engineering	Segment Routing traffic engineering
PE1(config-sr-te)#policy 1	Policy configuration with name 1
PE1(config-sr-pol)#color 1 end-point 1.1.1.9	SR-policy color and end-point
PE1(config-sr-pol-cp)#candidate-path 1	SR policy candidate path
PE1(config-sr-pol-cp)#preference 100	Candidate Path preference
PE1(config-sr-pol-cp)#dynamic-path isis 1	Dynamic candidate path as ISIS
PE1(config-sr-pol-cp)#constraints	Specify constraints
PE1(config-sr-dyn-cp-cons)#1.1.1.6 loose	Loopback IP of P2 as loose constraint
PE1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode
PE1(config-sr-pol)#candidate-path 2	SR policy candidate path

PE1(config-sr-pol-cp)#dynamic-path isis 1	Dynamic candidate path as ISIS
PE1(config-sr-pol-cp)#constraints	Specify constraints
PE1(config-sr-dyn-cp-cons)#10.1.2.2 strict	Interface IP of P1 as strict constraint
PE1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode
PE1(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode
PE1(config-sr-te)#exit-te	Exit from traffic engineering configuration mode
PE1(config)#ip vrf vrf1	Configure VPN Routing/Forwarding instance
PE1(config-vrf)#rd 100:2	route distinguisher
PE1(config-vrf)#route-target both 200:1	route target
PE1(config-vrf)#exit	Exit VRF mode.
PE1(config)#interface eth3	Enter interface mode.
PE1(config-if)#ip vrf forwarding vrf1	Configuring interface for VRF forwarding
PE1(config-if)#ip address 177.1.1.1/24	Configure the IP address of the interface.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router bgp 100	Configure router bgp in AS 100
PE1(config-router)#neighbor 1.1.1.9 remote-as 100	Configure neighbor in remote-as 100
PE1(config-router)#neighbor 1.1.1.9 update-source lo	Configure neighbor with update-source loopback
PE1(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE1(config-router-af)#neighbor 1.1.1.9 activate	Activate VPNv4 neighbor
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#address-family ipv4 vrf vrf1	Enter address-family VRF
PE1(config-router-af)#redistribute connected	Redistribute all the connected VRF routes
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#exit	Exit router mode.
PE1(config)#commit	Commit candidate configuration to be running configuration
PE1(config)#exit	Exit configuration mode

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 1.1.1.2/32 secondary	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1

	instance.
P1(config-if)#prefix-sid index 2	Configure prefix sid index value.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth1	Enter interface mode.
P1(config-if)#ip address 10.1.2.2/24	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode
P1(config)#interface eth2	Enter interface mode.
P1(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode
P1(config)#interface eth3	Enter interface mode.
P1(config-if)#ip address 29.1.1.1/24	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#router isis 1	Set the routing process ID .
P1(config-router)#metric-style wide	Configure metric style as wide.
P1(config)#commit	Commit candidate configuration to be running configuration
P1(config-router)#is-type level-1	Configure is-type.
P1(config-router)#net 49.0001.0000.0000.0001.00	Configure Network entity title (NET).
P1(config-router)#mpls traffic-eng router-id 1.1.1.2	Enable MPLS Traffic Engineering under router process.
P1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P1(config-router)#capability cspf	Enable cspf capability under ISIS 1 process.
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)#exit	Exit router mode.
P1(config)#commit	Commit candidate configuration to be running configuration
P1(config)#exit	Exit configuration mode

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 1.1.1.6/32 secondary	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#prefix-sid index 3	Configure prefix sid index value.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth1	Enter interface mode.
P2(config-if)#ip address 50.1.1.2/24	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config)#interface eth2	Enter interface mode.
P2(config-if)#ip address 10.1.6.2/24	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config)#interface eth3	Enter interface mode.
P2(config-if)#ip address 29.1.1.2/24	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#router isis 1	Set the routing process ID .
P2(config-router)#metric-style wide	Configure metric style as wide.
P2(config)#commit	Commit candidate configuration to be running configuration
P2(config-router)#is-type level-1	Configure is-type.
P2(config-router)#net 49.0001.0000.0000.0002.00	Configure Network entity title (NET).
P2(config-router)#mpls traffic-eng router-id 1.1.1.6	Enable MPLS Traffic Engineering under router process.
P2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P2(config-router)#capability cspf	Enable cspf capability under ISIS 1 process.
P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)#exit	Exit router mode.

P2(config)#commit	Commit candidate configuration to be running configuration
P2(config)#exit	Exit configuration mode

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface lo	Enter interface mode.
P3(config-if)#ip address 1.1.1.4/32 secondary	Configure the IP address of the interface.
P3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#prefix-sid index 4	Configure prefix sid index value.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth1	Enter interface mode.
P3(config-if)#ip address 10.4.9.1/24	Configure the IP address of the interface.
P3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)#ip address 20.1.1.2/24	Configure the IP address of the interface.
P3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth3	Enter interface mode.
P3(config-if)#ip address 45.1.1.2/24	Configure the IP address of the interface.
P3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#router isis 1	Set the routing process ID .
P3(config-router)#metric-style wide	Configure metric style as wide.
P3(config)#commit	Commit candidate configuration to be running configuration
P3(config-router)#is-type level-1	Configure is-type.

P3(config-router)#net 49.0001.0000.0000.0003.00	Configure Network entity title (NET).
P3(config-router)#mpls traffic-eng router-id 1.1.1.4	Enable MPLS Traffic Engineering under router process.
P3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P3(config-router)#capability cspf	Enable cspf capability under ISIS 1 process.
P3(config-router)#segment-routing mpls	Enable segment routing under router process.
P3(config-router)#exit	Exit router mode.
P3(config)#commit	Commit candidate configuration to be running configuration
P3(config)#exit	Exit configuration mode

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface lo	Enter interface mode.
P4(config-if)#ip address 1.1.1.8/32 secondary	Configure the IP address of the interface.
P4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P4(config-if)#prefix-sid index 5	Configure prefix sid index value.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)#ip address 50.1.1.1/24	Configure the IP address of the interface.
P4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)#ip address 10.8.9.1/24	Configure the IP address of the interface.
P4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth3	Enter interface mode.
P4(config-if)#ip address 45.1.1.1/24	Configure the IP address of the interface.
P4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#router isis 1	Set the routing process ID .
P4(config-router)#metric-style wide	Configure metric style as wide.
P4(config)#commit	Commit candidate configuration to be running configuration
P4(config-router)#is-type level-1	Configure is-type.
P4(config-router)#net 49.0001.0000.0000.0004.00	Configure Network entity title (NET).
P4(config-router)#mpls traffic-eng router-id 1.1.1.8	Enable MPLS Traffic Engineering under router process.
P4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P4(config-router)#capability cspf	Enable cspf capability under ISIS 1 process.
P4(config-router)#segment-routing mpls	Enable segment routing under router process.
P4(config-router)#exit	Exit router mode.
P4(config)#commit	Commit candidate configuration to be running configuration
P4(config)#exit	Exit configuration mode

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 1.1.1.9/32 secondary	Configure the IP address of the interface.
PE2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE2(config-if)#prefix-sid index 6	Configure prefix sid index value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth1	Enter interface mode.
PE2(config-if)#ip address 10.4.9.2/24	Configure the IP address of the interface.
PE2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE2(config-if)#label-switching	Enable label switching.
PE2(config)#interface eth2	Enter interface mode.
PE2(config-if)#ip address 10.8.9.2/24	Configure the IP address of the interface.
PE2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router isis 1	Set the routing process ID .
PE2(config-router)#metric-style wide	Configure metric style as wide.
PE2(config)#commit	Commit candidate configuration to be running configuration
PE2(config-router)#is-type level-1	Configure is-type.
PE2(config-router)#net 49.0001.0000.0000.0022.00	Configure Network entity title (NET).
PE2(config-router)#mpls traffic-eng router-id 1.1.1.9	Enable MPLS Traffic Engineering under router process.
PE2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE2(config-router)#capability cspf	Enable cspf capability under ISIS 1 process.
PE2(config-router)#segment-routing mpls	Enable segment routing under router process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#ip vrf vrf1	Configure VPN Routing/Forwarding instance
PE2(config-vrf)#rd 100:1	route distinguisher
PE2(config-vrf)#route-target both 200:1	route target
PE2(config-vrf)#exit	Exit VRF mode.
PE2(config)#interface eth3	Enter interface mode.
PE2(config-if)#ip vrf forwarding vrf1	Configuring interface for VRF forwarding
PE2(config-if)#ip address 202.1.1.2/24	Configure the IP address of the interface.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router bgp 100	Configure router bgp in AS 100
PE2(config-router)#neighbor 1.1.1.1 remote-as 100	Configure neighbor in remote-as 100
PE2(config-router)#neighbor 1.1.1.1 update-source lo	Configure neighbor with update-source loopback
PE2(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE2(config-router-af)#neighbor 1.1.1.1 activate	Activate VPNv4 neighbor
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#address-family ipv4 vrf vrf1	Enter address-family VRF
PE2(config-router-af)#redistribute connected	Redistribute all the connected VRF routes
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit candidate configuration to be running configuration
PE2(config)#exit	Exit configuration mode

Validation

Validation 1

Verify ISIS neighbor adjacency between routers and show segment-routing policy detail

```

PE1#show  clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag 1:  VRF : default
System Id      Interface      SNPA                State  Holdtime  Type Protocol
0000.0000.0001 eth1          04f8.f865.9009      Up     8          L1   IS-IS
0000.0000.0002 eth2          b86a.97d0.25d4      Up     9          L1   IS-IS

PE1#

PE1#show segment-routing policy detail

Policy-Name: 1      Color 1      End-point 1.1.1.9      Tunnel-ID: 1
Admin-Status: UP    Oper-Status: UP for 00:02:37
State Transition Count: 1
CSPF Retry Limit: 100    CSPF Retry Interval: 10
Binding SID :
BSID: 24960
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 2, Active
Preference: 100    Path Type: Dynamic(isis)    CP Origin: Local
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :24320
Segment1[LABEL]: Label :16006
Out-if: eth1      Out-label-stack: 3/16006
Attributes:
Configured:
Affinity:
Metric-type: TE
IP Constraints: 10.1.2.2 strict

CP ID: 1
Preference: 100    Path Type: Dynamic(isis)    CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :16003
Segment1[LABEL]: Label :16006
Out-if: eth2      Out-label-stack: 3/16006
Attributes:
Configured:
Affinity:
Metric-type: TE
IP Constraints: 1.1.1.6 loose

PE1#

```

Validation 2

Verify the prefix SIDs are installed as labels in MPLS forwarding table. Verify the same in FTN and ILM tables.

```
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, SR: Disabled
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
i>	1.1.1.2/32	1	20	-	-	-	-
	0	00:14:44	18	0	Yes	3	eth1 No 10.
1.2.2	-	-	22	-	-	-	-
i>	1.1.1.4/32	3	21	0	Yes	16004	eth1 No 10.
	0	00:05:54	21	0	Yes	16004	eth1 No 10.
1.2.2	-	-	6	-	-	-	-
i>	1.1.1.6/32	2	1	0	Yes	3	eth2 No 10.
	0	00:14:44	1	0	Yes	3	eth2 No 10.
1.6.2	-	-	11	-	-	-	-
i>	1.1.1.8/32	4	10	0	Yes	16005	eth2 No 10.
	0	00:03:53	10	0	Yes	16005	eth2 No 10.
1.6.2	-	-	25	-	-	-	-
i>	1.1.1.9/32	5	24	0	Yes	16006	eth1 No 10.
	0	00:01:58	24	0	Yes	16006	eth1 No 10.
1.2.2	-	-	13	0	Yes	16006	eth2 No 10.
	-	-	13	0	Yes	16006	eth2 No 10.
1.6.2	-	-					

```
PE1#
```

```
PE1#
```

```
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, UPStr - upstream
```

```
ILM-ECMP LDP: Disabled, SR: Disabled
```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop	pri	Algo-Num	UpTime	UPStr peers	
i>	1.1.1.4/32	5	16004	16004	N/A	eth1 10.1.2.2
Yes	0	00:06:02				
i>	1.1.1.2/32	3	16002	3	N/A	eth1 10.1.2.2
Yes	0	00:14:52				
i>	1.1.1.1/32	1	16001	Nolabel	N/A	N/A 127.0.0.1
Yes	0	00:32:32				
i>	1.1.1.6/32	4	16003	3	N/A	eth2 10.1.6.2
Yes	0	00:14:52				
i>	1.1.1.9/32	7	16006	16006	N/A	eth1 10.1.2.2
Yes	0	00:02:06				
	-	-	16006	16006	N/A	eth2 10.1.6.2
Yes	-	-				
i>	1.1.1.8/32	6	16005	16005	N/A	eth2 10.1.6.2
Yes	0	00:04:01				
i>	10.1.6.2/32	2	24960	3	N/A	eth2 10.1.6.2
Yes	0	00:14:57				
i>	10.1.2.2/32	8	24961	3	N/A	eth1 10.1.2.2
Yes	0	00:00:57				

```
PE1#
PE1#

PE1#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: eth1, out label: 3
Nexthop addr: 10.1.2.2      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 1.1.1.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16004
Nexthop addr: 10.1.2.2      cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 1.1.1.6/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 2, owner: N/A, Stale: NO, out intf: eth2, out label: 3
Nexthop addr: 10.1.6.2      cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 1.1.1.8/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: 7
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: ISIS-SR, Stale: NO, out intf: eth2, out label: 16005
Nexthop addr: 10.1.6.2      cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 1.1.1.9/32, id: 7, row status: Active, Tunnel-Policy: N/A
Owner: SR_POLICY, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 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: eth1, out label: 3\16006
Nexthop addr: 10.1.2.2      cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 1.1.1.9/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: 10
Owner: ISIS-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 10, owner: ISIS-SR, Stale: NO, out intf: eth1, out label: 16006
Nexthop addr: 10.1.2.2      cross connect ix: 6, op code: Push

PE1#
```

Validation 3

The command output below displays the details of routers configured with segment routing

```

PE1#show isis segment-routing state

Tag 1 Segment-Routing:
SR State: SR_ENABLED
SRGB Start: 16000, SRGB Range: 8000
Operational state: enabled
PE1#
PE1#show isis segment-routing capability

Tag 1 Segment-Routing:
-----
Advertisement Router Capability :1.1.1.1
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.2
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.4
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.6
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.8
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.9
Algorithm                      :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
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
0000.0000.0001.00-00 0x0000000E  0x83F8        426           0/0/0
  Area Address: 49.0001
  NLPID:       0xCC
  IP Address:  1.1.1.2

```



```

Router ID:      1.1.1.2
Router Cap:     1.1.1.2
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0001.02
  IPv4 Interface Address: 10.1.2.2
  Neighbor IP Address: 10.1.2.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0011 LAN Adjacency SID: 24320   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0002.04
  IPv4 Interface Address: 29.1.1.1
  Neighbor IP Address: 29.1.1.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0002 LAN Adjacency SID: 24321   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0003.03
  IPv4 Interface Address: 20.1.1.1
  Neighbor IP Address: 20.1.1.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0003 LAN Adjacency SID: 24322   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IP-Extended 1.1.1.2/32
  Prefix-SID: index 2 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 10.1.2.0/24
Metric: 10      IP-Extended 20.1.1.0/24
Metric: 10      IP-Extended 29.1.1.0/24
0000.0000.0001.02-00 0x00000004 0xAF0A 426 0/0/0
Metric: 0        IS-Extended 0000.0000.0001.00
Metric: 0        IS-Extended 0000.0000.0011.00
0000.0000.0002.00-00 0x00000009 0x325C 426 0/0/0
Area Address: 49.0001
NLPID: 0xCC
IP Address: 1.1.1.6
Router ID: 1.1.1.6
Router Cap: 1.1.1.6
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0

```

```

SR-Algorithm:
  Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0002.03
IPv4 Interface Address: 10.1.6.2
Neighbor IP Address: 10.1.6.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0011 LAN Adjacency SID: 24321  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0002.04
IPv4 Interface Address: 29.1.1.2
Neighbor IP Address: 29.1.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0001 LAN Adjacency SID: 24320  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0002.02
IPv4 Interface Address: 50.1.1.2
Neighbor IP Address: 50.1.1.2
Maximum Link Bandwidth: 100g
Reservable Bandwidth: 100g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100g
  Unreserved Bandwidth at priority 1: 100g
  Unreserved Bandwidth at priority 2: 100g
  Unreserved Bandwidth at priority 3: 100g
  Unreserved Bandwidth at priority 4: 100g
  Unreserved Bandwidth at priority 5: 100g
  Unreserved Bandwidth at priority 6: 100g
  Unreserved Bandwidth at priority 7: 100g
TE-Default Metric: 10
System-ID: 0000.0000.0004 LAN Adjacency SID: 24322  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IP-Extended 1.1.1.6/32
Prefix-SID: index 3 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 29.1.1.0/24
Metric: 10      IP-Extended 10.1.6.0/24
Metric: 10      IP-Extended 50.1.1.0/24
0000.0000.0002.02-00 0x00000004 0xAB19 1005 0/0/0
Metric: 0      IS-Extended 0000.0000.0002.00
Metric: 0      IS-Extended 0000.0000.0004.00
0000.0000.0002.03-00 0x00000003 0xAB0C 426 0/0/0
Metric: 0      IS-Extended 0000.0000.0002.00
Metric: 0      IS-Extended 0000.0000.0011.00
0000.0000.0002.04-00 0x00000003 0x6363 512 0/0/0
Metric: 0      IS-Extended 0000.0000.0002.00
Metric: 0      IS-Extended 0000.0000.0001.00
0000.0000.0003.00-00 0x0000000D 0x4BA3 545 0/0/0
Area Address: 49.0001
NLPID: 0xCC
IP Address: 1.1.1.4

```

```

Router ID:      1.1.1.4
Router Cap:     1.1.1.4
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0003.03
  IPv4 Interface Address: 20.1.1.2
  Neighbor IP Address: 20.1.1.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0001   LAN Adjacency SID: 24320   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0004.04
  IPv4 Interface Address: 45.1.1.2
  Neighbor IP Address: 45.1.1.1
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0004   LAN Adjacency SID: 24321   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0022.02
  IPv4 Interface Address: 10.4.9.1
  Neighbor IP Address: 10.4.9.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0022   LAN Adjacency SID: 24322   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IP-Extended 1.1.1.4/32
  Prefix-SID: index 4 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 10.4.9.0/24
Metric: 10      IP-Extended 20.1.1.0/24
Metric: 10      IP-Extended 45.1.1.0/24
0000.0000.0003.03-00 0x00000003 0x6B5A 775 0/0/0
  Metric: 0      IS-Extended 0000.0000.0003.00
  Metric: 0      IS-Extended 0000.0000.0001.00
0000.0000.0004.00-00 0x00000009 0xFA0A 545 0/0/0
  Area Address: 49.0001
  NLPID: 0xCC
  IP Address: 1.1.1.8
  Router ID: 1.1.1.8
  Router Cap: 1.1.1.8
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0

```

```

SR-Algorithm:
  Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0002.02
IPv4 Interface Address: 50.1.1.1
Neighbor IP Address: 50.1.1.2
Maximum Link Bandwidth: 100g
Reservable Bandwidth: 100g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100g
  Unreserved Bandwidth at priority 1: 100g
  Unreserved Bandwidth at priority 2: 100g
  Unreserved Bandwidth at priority 3: 100g
  Unreserved Bandwidth at priority 4: 100g
  Unreserved Bandwidth at priority 5: 100g
  Unreserved Bandwidth at priority 6: 100g
  Unreserved Bandwidth at priority 7: 100g
TE-Default Metric: 10
System-ID: 0000.0000.0002 LAN Adjacency SID: 24321  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0004.04
IPv4 Interface Address: 45.1.1.1
Neighbor IP Address: 45.1.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0003 LAN Adjacency SID: 24320  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0022.03
IPv4 Interface Address: 10.8.9.1
Neighbor IP Address: 10.8.9.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0022 LAN Adjacency SID: 24322  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IP-Extended 1.1.1.8/32
  Prefix-SID: index 5 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 10.8.9.0/24
Metric: 10      IP-Extended 45.1.1.0/24
Metric: 10      IP-Extended 50.1.1.0/24
0000.0000.0004.04-00 0x00000003 0x8D33 1006 0/0/0
Metric: 0      IS-Extended 0000.0000.0004.00
Metric: 0      IS-Extended 0000.0000.0003.00
0000.0000.0011.00-00* 0x0000000E 0xE5FA 432 0/0/0
Area Address: 49.0001
NLPID: 0xCC
IP Address: 1.1.1.1
Router ID: 1.1.1.1
Router Cap: 1.1.1.1
  SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
  Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0001.02

```

```

IPv4 Interface Address: 10.1.2.1
Neighbor IP Address: 10.1.2.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended 0000.0000.0002.03
IPv4 Interface Address: 10.1.6.1
Neighbor IP Address: 10.1.6.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0002 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 1.1.1.1/32
    Prefix-SID: index 1 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/24
Metric: 10 IP-Extended 10.1.6.0/24
0000.0000.0022.00-00 0x00000005 0xC06F 550 0/0/0
Area Address: 49.0001
NLPID: 0xCC
IP Address: 1.1.1.9
Router ID: 1.1.1.9
Router Cap: 1.1.1.9
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
    Algorithm: 0
Metric: 10 IS-Extended 0000.0000.0022.03
IPv4 Interface Address: 10.8.9.2
Neighbor IP Address: 10.8.9.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0004 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended 0000.0000.0022.02
IPv4 Interface Address: 10.4.9.2
Neighbor IP Address: 10.4.9.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g

```

```

    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    System-ID: 0000.0000.0003 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 1.1.1.9/32
    Prefix-SID: index 6 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 10 IP-Extended 10.8.9.0/24
    Metric: 10 IP-Extended 10.4.9.0/24
    0000.0000.0022.02-00 0x00000002 0xBBCB 541 0/0/0
    Metric: 0 IS-Extended 0000.0000.0022.00
    Metric: 0 IS-Extended 0000.0000.0003.00
    0000.0000.0022.03-00 0x00000002 0xC8BC 541 0/0/0
    Metric: 0 IS-Extended 0000.0000.0022.00
    Metric: 0 IS-Extended 0000.0000.0004.00

PE1#
PE1#show cspf lsp isis 1
LSP detail
  Trunk ID : 1
  LSP ID : 1
  ISIS Tag Name : 1
  Client ID : 0
  State : Established(3)
  Ingress : 1.1.1.9
  Egress : 1.1.1.9
  Ext Tunnel ID : 1.1.1.9
  LSP Type : 0
  Setup Priority : 7
  Hold Priority : 0
  Hop Limit : 255
  Retry Interval : 10
  Retry Limit : 10
  LSP Metric : 30
  Path Constraint :
    1.1.1.6 loose
  Computed ERO :
    10.1.6.2
    50.1.1.1
    10.8.9.2

LSP detail
  Trunk ID : 1
  LSP ID : 2
  ISIS Tag Name : 1
  Client ID : 0
  State : Established(3)
  Ingress : 1.1.1.9
  Egress : 1.1.1.9
  Ext Tunnel ID : 1.1.1.9
  LSP Type : 0
  Setup Priority : 7
  Hold Priority : 0
  Hop Limit : 255
  Retry Interval : 10
  Retry Limit : 10
  LSP Metric : 30
  Path Constraint :
    10.1.2.2 strict
  Computed ERO :
    10.1.2.2
    20.1.1.2
    10.4.9.2

PE1#show cspf lsp isis 1

```

```
LSP detail
  Trunk ID           : 1
  LSP ID             : 1
  ISIS Tag Name      : 1
  Client ID          : 0
  State              : Established(3)
  Egress             : 1.1.1.9
  Ext Tunnel ID      : 1.1.1.9
  LSP Type           : 0
  Retry Interval     : 10
  Retry Timer        : OFF
  Retry Limit        : 100
  Remaining Retry Count : 0
  LSP Metric         : 30
  Path Constraint    :
    1.1.1.6         loose
  Computed ERO       :
    10.1.6.2
    50.1.1.1
    10.8.9.2
```

```
LSP detail
  Trunk ID           : 1
  LSP ID             : 2
  ISIS Tag Name      : 1
  Client ID          : 0
  State              : Established(3)
  Egress             : 1.1.1.9
  Ext Tunnel ID      : 1.1.1.9
  LSP Type           : 0
  Retry Interval     : 10
  Retry Timer        : OFF
  Retry Limit        : 100
  Remaining Retry Count : 0
  LSP Metric         : 30
  Path Constraint    :
    10.1.2.2         strict
  Computed ERO       :
    10.1.2.2
    20.1.1.2
    10.4.9.2
```

PE1#

Validation 4

Validation of MPLS vrf-table

```
PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 2
Primary FTN entry with FEC: 202.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 1
  Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 12
  Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 12, owner: BGP, Stale: NO, BGP out intf: eth1, transport out intf:
eth1, out label: 24960
  Nexthop addr: 1.1.1.9          cross connect ix: 8, op code: Push and Lookup
```

PE1#

Dynamic Path Policy with OSPF Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

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 the IP address of the interface.
PE1(config-if)#prefix-sid index 1	Configure prefix sid index value.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.
PE1(config-if)#ip address 10.1.2.1/24	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config)#interface eth2	Enter interface mode.
PE1(config-if)#ip address 10.1.6.1/24	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router ospf 1	Set the routing process ID .
PE1(config-router)#ospf router-id 1.1.1.1	Configuring ospf router-id
PE1(config-router)#network 1.1.1.1/32 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#network 10.1.2.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#network 10.1.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#segment-routing mpls	Enable segment routing under router process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#segment-routing	Configuring segment-routing
PE1(config-sr)#traffic-engineering	Segment Routing traffic engineering
PE1(config-sr-te)#policy 1	Policy configuration with name 1
PE1(config-sr-pol)#color 1 end-point 1.1.1.9	SR-policy color and end-point
PE1(config-sr-pol-cp)#candidate-path 1	SR policy candidate path
PE1(config-sr-pol-cp)#preference 100	Candidate Path preference
PE1(config-sr-pol-cp)#dynamic-path ospf 1	Dynamic candidate path as ospf
PE1(config-sr-pol-cp)#constraints	Specify constraints
PE1(config-sr-dyn-cp-cons)#1.1.1.6 loose	Loopback IP of P2 as loose constraint
PE1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode
PE1(config-sr-pol)#candidate-path 2	SR policy candidate path

PE1(config-sr-pol-cp)#dynamic-path ospf 1	Dynamic candidate path as ospf
PE1(config-sr-pol-cp)#constraints	Specify constraints
PE1(config-sr-dyn-cp-cons)#10.1.2.2 strict	Interface IP of P1 as strict constraint
PE1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode
PE1(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode
PE1(config-sr-te)#exit-te	Exit from traffic engineering configuration mode
PE1(config)#ip vrf vrf1	Configure VPN Routing/Forwarding instance
PE1(config-vrf)#rd 100:2	route distinguisher
PE1(config-vrf)#route-target both 200:1	route target
PE1(config-vrf)#exit	Exit VRF mode.
PE1(config)#interface eth3	Enter interface mode.
PE1(config-if)#ip vrf forwarding vrf1	Configuring interface for VRF forwarding
PE1(config-if)#ip address 177.1.1.1/24	Configure the IP address of the interface.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router bgp 100	Configure router bgp in AS 100
PE1(config-router)#neighbor 1.1.1.9 remote-as 100	Configure neighbor in remote-as 100
PE1(config-router)#neighbor 1.1.1.9 update-source lo	Configure neighbor with update-source loopback
PE1(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE1(config-router-af)#neighbor 1.1.1.9 activate	Activate VPNv4 neighbor
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#address-family ipv4 vrf vrf1	Enter address-family VRF
PE1(config-router-af)#redistribute connected	Redistribute all the connected VRF routes
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#exit	Exit router mode.
PE1(config)#commit	Commit candidate configuration to be running configuration
PE1(config)#exit	Exit configuration mode

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 1.1.1.2/32 secondary	Configure the IP address of the interface.
P1(config-if)#prefix-sid index 2	Configure prefix sid index value.

P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth1	Enter interface mode.
P1(config-if)#ip address 10.1.2.2/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config)#interface eth2	Enter interface mode.
P1(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config)#interface eth3	Enter interface mode.
P1(config-if)#ip address 29.1.1.1/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#router ospf 1	Set the routing process ID .
P1(config-router)#network 1.1.1.2/32 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#ospf router-id 1.1.1.2	Configure OSPF router-id
P1(config-router)#network 10.1.2.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 20.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 29.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)#exit	Exit router mode.
P1(config)#commit	Commit candidate configuration to be running configuration
P1(config)#exit	Exit configuration mode

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 1.1.1.6/32 secondary	Configure the IP address of the interface.
P2(config-if)#prefix-sid index 3	Configure prefix sid index value.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth1	Enter interface mode.
P2(config-if)#ip address 50.1.1.2/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config)#interface eth2	Enter interface mode.

P2(config-if)#ip address 10.1.6.2/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config)#interface eth3	Enter interface mode.
P2(config-if)#ip address 29.1.1.2/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ospf 1	Set the routing process ID .
P2(config-router)#ospf router-id 1.1.1.6	Configure ospf router-id
P2(config-router)#network 1.1.1.6/32 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 10.1.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 29.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 50.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)#exit	Exit router mode.
P2(config)#commit	Commit candidate configuration to be running configuration
P2(config)#exit	Exit configuration mode

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface lo	Enter interface mode.
P3(config-if)#ip address 1.1.1.4/32 secondary	Configure the IP address of the interface.
P3(config-if)#prefix-sid index 4	Configure prefix sid index value.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth1	Enter interface mode.
P3(config-if)#ip address 10.4.9.1/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)#ip address 20.1.1.2/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config)#interface eth3	Enter interface mode.
P3(config-if)#ip address 45.1.1.2/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.

P3(config-if)#exit	Exit interface mode.
P3(config)#router ospf 1	Set the routing process ID .
P3(config-router)#ospf router-id 1.1.1.4	Configuring ospf router-id
P3(config-router)#network 1.1.1.4/32 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 10.4.9.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 20.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 45.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#segment-routing mpls	Enable segment routing under router process.
P3(config-router)#exit	Exit router mode.
P3(config)#commit	Commit candidate configuration to be running configuration
P3(config)#exit	Exit configuration mode

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface lo	Enter interface mode.
P4(config-if)#ip address 1.1.1.8/32 secondary	Configure the IP address of the interface.
P4(config-if)#prefix-sid index 5	Configure prefix sid index value.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)#ip address 50.1.1.1/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)#ip address 10.8.9.1/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.
P4(config)#interface eth3	Enter interface mode.
P4(config-if)#ip address 45.1.1.1/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#router ospf 1	Set the routing process ID .
P4(config-router)#ospf router-id 1.1.1.8	Configuring ospf router-id
P4(config-router)#network 1.1.1.8/32 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#network 10.8.9.0/24 area 0.0.0.0	Configure OSPF network in area 0

P4(config-router)#network 45.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#network 50.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#segment-routing mpls	Enable segment routing under router process.
P4(config-router)#exit	Exit router mode.
P4(config)#commit	Commit candidate configuration to be running configuration
P4(config)#exit	Exit configuration mode

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 1.1.1.9/32 secondary	Configure the IP address of the interface.
PE2(config-if)#prefix-sid index 6	Configure prefix sid index value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth1	Enter interface mode.
PE2(config-if)#ip address 10.4.9.2/24	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config)#interface eth2	Enter interface mode.
PE2(config-if)#ip address 10.8.9.2/24	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router ospf 1	Set the routing process ID .
PE2(config-router)#router-id 1.1.1.9	Configuring ospf router-id
PE2(config-router)#network 1.1.1.9/32 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#network 10.4.9.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#network 10.8.9.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#segment-routing mpls	Enable segment routing under router process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#ip vrf vrf1	Configure VPN Routing/Forwarding instance
PE2(config-vrf)#rd 100:1	route distinguisher
PE2(config-vrf)#route-target both 200:1	route target
PE2(config-vrf)#exit	Exit VRF mode.

PE1(config)#interface eth3	Enter interface mode.
PE1(config-if)#ip vrf forwarding vrf1	Configuring interface for VRF forwarding
PE1(config-if)#ip address 177.1.1.2/24	Configure the IP address of the interface.
PE1(config-if)#exit	Exit interface mode.
PE2(config)#router bgp 100	Configure router bgp in AS 100
PE2(config-router)#neighbor 1.1.1.1 remote-as 100	Configure neighbor in remote-as 100
PE2(config-router)#neighbor 1.1.1.1 update-source lo	Configure neighbor with update-source loopback
PE2(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE2(config-router-af)#neighbor 1.1.1.1 activate	Activate VPNv4 neighbor
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#address-family ipv4 vrf vrf1	Enter address-family VRF
PE2(config-router-af)#redistribute connected	Redistribute all the connected VRF routes
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit candidate configuration to be running configuration
PE2(config)#exit	Exit configuration mode

Validation

Validation 1

Verify OSPF neighbor adjacency between routers and show segment-routing policy detail.

```
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
1.1.1.2	1	Full/DR	00:00:39	10.1.2.2	eth1	0
1.1.1.6	1	Full/DR	00:00:33	10.1.6.2	eth2	0

```
PE1#show segment-routing policy
```

Policy-Name	State	Forwarding-Info	Color	End-	
point					
1			1	1.1.1.9	UP

```
PE1#
```

```
PE1#show segment-routing policy detail
```

```
Policy-Name: 1      Color 1      End-point 1.1.1.9      Tunnel-ID: 1
Admin-Status: UP    Oper-Status: UP for 03:24:33
State Transition Count: 3
CSPF Retry Limit: 100    CSPF Retry Interval: 10
Binding SID :
BSID: 24960
Alloc mode: Dynamic
```

```

Oper State: Programmed

CP ID: 2, Active
  Preference: 100      Path Type: Dynamic(ospf)      CP Origin: Local
  Segment List:
    Total no. of segments: 2
    Segment0[LABEL]: Label :24320
    Segment1[LABEL]: Label :16006
  Out-if: xe7          Out-label-stack: 3/16006
  Attributes:
    Configured:
    Affinity:
    Metric-type: TE
    IP Constraints: 10.1.2.2 strict

CP ID: 1
  Preference: 100      Path Type: Dynamic(ospf)      CP Origin: Local
  CP state: Valid
  Segment List:
    Total no. of segments: 2
    Segment0[LABEL]: Label :16003
    Segment1[LABEL]: Label :16006
  Out-if: xe13         Out-label-stack: 3/16006
  Attributes:
    Configured:
    Affinity:
    Metric-type: TE
    IP Constraints: 1.1.1.6 loose

PE1#

```

Validation 2

Verify the prefix SIDs are installed as labels in MPLS forwarding table. Verify the same in FTN and ILM tables.

```

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, SR: Disabled
Code   FEC           FTN-ID  Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC    Nexthop    Algo-Num  UpTime
O>    1.1.1.2/32    1        3         -         -    -         -
-      -          0        00:09:00
          1         0        Yes    3         eth1      No
10.1.2.2  -      -
O>    1.1.1.4/32    3        1 1       -         -    -         -
-      -          0        00:05:12
          10        0        Yes   16004      eth1      No
10.1.2.2  -      -
O>    1.1.1.6/32    2        9         -         -    -         -
-      -          0        00:06:59
          7         0        Yes    3         eth2      No
10.1.6.2  -      -
O>    1.1.1.8/32    4        14        -         -    -         -
-      -          0        00:02:13
          13        0        Yes   16005      eth2      No
10.1.6.2  -      -
P>    1.1.1.9/32    6        21        1        Yes    3         eth1      No
10.1.2.2  N/A      00:00:44
O>    1.1.1.9/32    5        18        -         -    -         -
-      -          0        00:00:53

```

```

10.1.2.2    -      -      16      0      Yes  16006      eth1      No
10.1.6.2    -      -PE1#  17      0      Yes  16006      eth2      No
PE1#

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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code  FEC/VRF/L2CKT  ILM-ID  In-Label  Out-Label  In-Intf  Out-
Intf/VRF  Nexthop  pri  Algo-Num  UpTime  UPStr peers
O>  1.1.1.4/32      5      16004      16004      N/A      eth1      10.1
.2.2      Yes  0      00:05:16
O>  1.1.1.6/32      3      16003      3          N/A      eth2      10.1
.6.2      Yes  0      00:07:03
O>  1.1.1.2/32      2      16002      3          N/A      eth1      10.1
.2.2      Yes  0      00:09:04
O>  10.1.2.2/32     1      25600      3          N/A      eth1      10.1
.2.2      Yes  0      00:09:06
O>  1.1.1.9/32      7      16006      16006      N/A      eth1      10.1
.2.2      Yes  0      00:00:57
          16006      16006      N/A      eth2      10.
1.6.2      Yes  -      -
O>  1.1.1.8/32      6      16005      16005      N/A      eth2      10.1
.6.2      Yes  0      00:02:17
P>  1.1.1.9/32      8      24960      16006      N/A      eth1      10.1
.2.2      Yes  N/A     00:00:48
O>  10.1.6.2/32     4      25601      3          N/A      eth2      10.1
.6.2      Yes  0      00:07:02
PE1#
PE1#

PE1#show mpls ftn-table
Primary FTN entry with FEC: 1.1.1.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource 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: xe7, out label: 3
Nexthop addr: 10.1.2.2      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 1.1.1.4/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 0
Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 5
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: OSPF-SR, Stale: NO, out intf: xe7, out label: 16004
Nexthop addr: 10.1.2.2      cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 1.1.1.9/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 0
Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 9
Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 9, owner: OSPF-SR, Stale: NO, out intf: xe7, out label: 16006
Nexthop addr: 10.1.2.2      cross connect ix: 6, op code: Push
PE1#

```


Validation 3

The command output below displays the details of routers configured with segment routing.

```

PE1#show ip ospf segment-routing capability

OSPF process 1:
-----
Advertisement Router Capability :1.1.1.1
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.2
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.4
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.6
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.8
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
Advertisement Router Capability :1.1.1.9
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
-----
PE1#

PE1#show ip ospf database opaque-area

      OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)

          Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 1648
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 1.1.1.1
LS Seq Number: 8000000a
Checksum: 0x1eff
Length: 28

MPLS TE router ID : 1.1.1.1

```

```
Number of Links : 0

LS age: 5
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 1.1.1.2
LS Seq Number: 8000000a
Checksum: 0x22f9
Length: 28

MPLS TE router ID : 1.1.1.2

Number of Links : 0

LS age: 28
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 1.1.1.4
LS Seq Number: 8000000a
Checksum: 0x2aed
Length: 28

MPLS TE router ID : 1.1.1.4

Number of Links : 0

LS age: 1788
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 1.1.1.6
LS Seq Number: 80000008
Checksum: 0x36df
Length: 28

MPLS TE router ID : 1.1.1.6

Number of Links : 0

LS age: 1621
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 1.1.1.8
LS Seq Number: 80000008
Checksum: 0x3ed3
Length: 28

MPLS TE router ID : 1.1.1.8

Number of Links : 0

LS age: 1812
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
```

```
Advertising Router: 1.1.1.9
LS Seq Number: 80000008
Checksum: 0x42cd
Length: 28
```

```
MPLS TE router ID : 1.1.1.9
```

```
Number of Links : 0
```

```
LS age: 1348
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.8 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 8
Advertising Router: 1.1.1.6
LS Seq Number: 80000007
Checksum: 0x9787
Length: 108
```

```
Link connected to Broadcast network
```

```
Link ID : 29.1.1.1
Interface Address : 29.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

```
Number of Links : 1
```

```
LS age: 418
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 22
Advertising Router: 1.1.1.1
LS Seq Number: 80000008
Checksum: 0xcd6c
Length: 108
```

```
Link connected to Broadcast network
```

```
Link ID : 10.1.2.1
Interface Address : 10.1.2.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

```
Number of Links : 1
```

```
LS age: 1435
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 22
Advertising Router: 1.1.1.2
```

LS Seq Number: 80000007
Checksum: 0xe751
Length: 108

Link connected to Broadcast network

Link ID : 10.1.2.1
Interface Address : 10.1.2.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1381
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.28 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 28
Advertising Router: 1.1.1.8
LS Seq Number: 80000007
Checksum: 0x1af7
Length: 108

Link connected to Broadcast network

Link ID : 10.8.9.1
Interface Address : 10.8.9.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1712
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.28 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 28
Advertising Router: 1.1.1.9
LS Seq Number: 80000007
Checksum: 0x32dd
Length: 108

Link connected to Broadcast network

Link ID : 10.8.9.1
Interface Address : 10.8.9.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

```
Number of Links : 1

LS age: 378
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.34 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 34
Advertising Router: 1.1.1.1
LS Seq Number: 80000008
Checksum: 0x1e08
Length: 108

Link connected to Broadcast network
Link ID : 10.1.6.1
Interface Address : 10.1.6.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1048
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 1.1.1.4
LS Seq Number: 80000007
Checksum: 0x21f4
Length: 108

Link connected to Broadcast network
Link ID : 10.4.9.1
Interface Address : 10.4.9.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1378
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.36 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 36
Advertising Router: 1.1.1.6
LS Seq Number: 80000007
Checksum: 0x0c13
Length: 108

Link connected to Broadcast network
Link ID : 10.1.6.1
```

```
Interface Address : 10.1.6.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 432
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.38 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 38
Advertising Router: 1.1.1.9
LS Seq Number: 80000008
Checksum: 0x0b02
Length: 108

Link connected to Broadcast network
Link ID : 10.4.9.1
Interface Address : 10.4.9.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1349
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.46 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 46
Advertising Router: 1.1.1.4
LS Seq Number: 80000007
Checksum: 0x8686
Length: 108

Link connected to Broadcast network
Link ID : 20.1.1.1
Interface Address : 20.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1255
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
```

```
Link State ID: 1.0.0.48 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 48
Advertising Router: 1.1.1.2
LS Seq Number: 80000007
Checksum: 0x60ad
Length: 108
```

Link connected to Broadcast network

```
Link ID : 20.1.1.1
Interface Address : 20.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

Number of Links : 1

```
LS age: 47
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.56 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 56
Advertising Router: 1.1.1.6
LS Seq Number: 80000008
Checksum: 0x0c3e
Length: 108
```

Link connected to Broadcast network

```
Link ID : 50.1.1.2
Interface Address : 50.1.1.2
Admin Metric : 1
Maximum bandwidth : 100000000.00 Kbits/s
Maximum reservable bandwidth : 100000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 100000000.00 Kbits/s      Priority 1 : 100000000.00 Kbits/s
Priority 2 : 100000000.00 Kbits/s      Priority 3 : 100000000.00 Kbits/s
Priority 4 : 100000000.00 Kbits/s      Priority 5 : 100000000.00 Kbits/s
Priority 6 : 100000000.00 Kbits/s      Priority 7 : 100000000.00 Kbits/s
```

Number of Links : 1

```
LS age: 15
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.66 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 66
Advertising Router: 1.1.1.2
LS Seq Number: 80000008
Checksum: 0x499f
Length: 108
```

Link connected to Broadcast network

```
Link ID : 29.1.1.1
Interface Address : 29.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
```

```

Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

Number of Links : 1

```

LS age: 1339
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.96 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 96
Advertising Router: 1.1.1.4
LS Seq Number: 80000007
Checksum: 0x297e
Length: 108

```

Link connected to Broadcast network

```

Link ID : 45.1.1.2
Interface Address : 45.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

Number of Links : 1

```

LS age: 161
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.96 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 96
Advertising Router: 1.1.1.8
LS Seq Number: 80000008
Checksum: 0xf0b2
Length: 108

```

Link connected to Broadcast network

```

Link ID : 45.1.1.2
Interface Address : 45.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

```

Number of Links : 1

```

LS age: 1201
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.106 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 106
Advertising Router: 1.1.1.8
LS Seq Number: 80000007
Checksum: 0xed2a

```


Length: 108

Link connected to Broadcast network

Link ID : 50.1.1.2

Interface Address : 50.1.1.1

Admin Metric : 1

Maximum bandwidth : 100000000.00 Kbits/s

Maximum reservable bandwidth : 100000000.00 Kbits/s

Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 100000000.00 Kbits/s

Priority 1 : 100000000.00 Kbits/s

Priority 2 : 100000000.00 Kbits/s

Priority 3 : 100000000.00 Kbits/s

Priority 4 : 100000000.00 Kbits/s

Priority 5 : 100000000.00 Kbits/s

Priority 6 : 100000000.00 Kbits/s

Priority 7 : 100000000.00 Kbits/s

Number of Links : 1

LS age: 878

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)

Opaque Type: 4

Opaque ID: 0

Advertising Router: 1.1.1.1

LS Seq Number: 80000008

Checksum: 0xe7ee

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm0: 0

LS age: 1405

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)

Opaque Type: 4

Opaque ID: 0

Advertising Router: 1.1.1.2

LS Seq Number: 80000007

Checksum: 0xe3f2

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm0: 0

LS age: 1749

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)

Opaque Type: 4

Opaque ID: 0

Advertising Router: 1.1.1.4

LS Seq Number: 80000007

Checksum: 0xd7fc

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm0: 0

LS age: 638

Options: 0x22 (-|-|DC|-|-|-|E|-)

LS Type: Area-Local Opaque-LSA

```
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 1.1.1.6
LS Seq Number: 80000008
Checksum: 0xc908
Length: 44
```

```
    Range Size: 8000
    Base-SID: 16000
    Algorithm0: 0
```

```
LS age: 1731
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 1.1.1.8
LS Seq Number: 80000007
Checksum: 0xbf11
Length: 44
```

```
    Range Size: 8000
    Base-SID: 16000
    Algorithm0: 0
```

```
LS age: 1432
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 1.1.1.9
LS Seq Number: 80000007
Checksum: 0xb916
Length: 44
```

```
    Range Size: 8000
    Base-SID: 16000
    Algorithm0: 0
```

```
LS age: 238
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.1
LS Seq Number: 80000008
Checksum: 0xc3ca
Length: 44
```

```
    Prefix type : Extended Prefix TLV
    Route Type: 1
    Prefix Length: 32
    AF: 0
    Flags: 0x40 (-|N|-|-|-|-|-)
    Address Prefix: 1.1.1.1
    Flags: 0x00 (-|-|-|-|-|-|-)
    MT-ID: 0
    Algorithm: 0
    SID: 1
```

```
LS age: 495
```

```
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.2
LS Seq Number: 80000008
Checksum: 0xe5a5
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 1.1.1.2
Flags: 0x00 (-|-|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2
```

```
LS age: 428
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.4
LS Seq Number: 80000008
Checksum: 0x2a5b
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 1.1.1.4
Flags: 0x00 (-|-|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 4
```

```
LS age: 1658
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.6
LS Seq Number: 80000007
Checksum: 0x2261
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 1.1.1.6
Flags: 0x00 (-|-|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 3
```

```
LS age: 491
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
```

```

Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.8
LS Seq Number: 80000008
Checksum: 0x6418
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 1.1.1.8
Flags: 0x00 (-|-|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 5

```

```

LS age: 1082
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.9
LS Seq Number: 80000007
Checksum: 0x88f1
Length: 44

```

```

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 1.1.1.9
Flags: 0x00 (-|-|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 6

```

```

LS age: 1668
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.18 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10002
Advertising Router: 1.1.1.6
LS Seq Number: 80000007
Checksum: 0x3675
Length: 48

```

```

Link Type: 2
Link ID: 29.1.1.1
Link Data: 29.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24321

```

```

LS age: 488
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 1.1.1.1

```

LS Seq Number: 80000008
Checksum: 0xa517
Length: 52

Link Type: 2
Link ID: 10.1.2.1
Link Data: 10.1.2.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.2
SID: 24320

LS age: 515
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 1.1.1.2
LS Seq Number: 80000008
Checksum: 0x17b5
Length: 48

Link Type: 2
Link ID: 10.1.2.1
Link Data: 10.1.2.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320

LS age: 1321
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.28 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10012
Advertising Router: 1.1.1.8
LS Seq Number: 80000007
Checksum: 0x0c82
Length: 52

Link Type: 2
Link ID: 10.8.9.1
Link Data: 10.8.9.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.9
SID: 24322

LS age: 372
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.28 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10012
Advertising Router: 1.1.1.9
LS Seq Number: 80000008
Checksum: 0x6640
Length: 48

Link Type: 2
Link ID: 10.8.9.1

```
Link Data: 10.8.9.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320
```

```
LS age: 1678
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.31 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10015
Advertising Router: 1.1.1.1
LS Seq Number: 80000007
Checksum: 0x7d2d
Length: 52
```

```
Link Type: 2
Link ID: 10.1.6.1
Link Data: 10.1.6.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.6
SID: 24321
```

```
LS age: 338
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 1.1.1.4
LS Seq Number: 80000008
Checksum: 0x890c
Length: 52
```

```
Link Type: 2
Link ID: 10.4.9.1
Link Data: 10.4.9.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.9
SID: 24322
```

```
LS age: 1488
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.32 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10016
Advertising Router: 1.1.1.6
LS Seq Number: 80000007
Checksum: 0x3387
Length: 48
```

```
Link Type: 2
Link ID: 10.1.6.1
Link Data: 10.1.6.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320
```

```
LS age: 1252
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.33 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10017
Advertising Router: 1.1.1.9
LS Seq Number: 80000007
Checksum: 0xe2c6
Length: 48
```

```
Link Type: 2
Link ID: 10.4.9.1
Link Data: 10.4.9.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24321
```

```
LS age: 1329
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.37 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10021
Advertising Router: 1.1.1.4
LS Seq Number: 80000007
Checksum: 0x7b32
Length: 48
```

```
Link Type: 2
Link ID: 20.1.1.1
Link Data: 20.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320
```

```
LS age: 145
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.38 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10022
Advertising Router: 1.1.1.2
LS Seq Number: 80000008
Checksum: 0x8216
Length: 52
```

```
Link Type: 2
Link ID: 20.1.1.1
Link Data: 20.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.4
SID: 24322
```

```
LS age: 1378
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.42 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10026
```

Advertising Router: 1.1.1.6
LS Seq Number: 80000007
Checksum: 0xeb63
Length: 52

Link Type: 2
Link ID: 50.1.1.2
Link Data: 50.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.8
SID: 24322

LS age: 1435
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.47 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10031
Advertising Router: 1.1.1.2
LS Seq Number: 80000007
Checksum: 0x304d
Length: 52

Link Type: 2
Link ID: 29.1.1.1
Link Data: 29.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.6
SID: 24321

LS age: 1529
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.62 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10046
Advertising Router: 1.1.1.4
LS Seq Number: 80000007
Checksum: 0x8bbc
Length: 52

Link Type: 2
Link ID: 45.1.1.2
Link Data: 45.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
Weight: 0
NBR ID: 1.1.1.8
SID: 24321

LS age: 1661
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.62 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10046
Advertising Router: 1.1.1.8
LS Seq Number: 80000007
Checksum: 0xf06d
Length: 48


```
Link Type: 2
Link ID: 45.1.1.2
Link Data: 45.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24320

LS age: 1021
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.67 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10051
Advertising Router: 1.1.1.8
LS Seq Number: 80000007
Checksum: 0x5eef
Length: 48

Link Type: 2
Link ID: 50.1.1.2
Link Data: 50.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
Weight: 0
SID: 24321

PE1#
```

Validation 4

```
PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 2
Primary FTN entry with FEC: 202.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 1
Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 10
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 10, owner: BGP, Stale: NO, BGP out intf: xe13, transport out intf: xe7,
out label: 24960
Nexthop addr: 1.1.1.9          cross connect ix: 9, op code: Push and Lookup
PE1#
```

Explicit Path Policy Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

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 the IP address of the interface.
PE1(config-if)#prefix-sid index 1	Configure prefix sid index value.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.

PE1(config-if)#ip address 10.1.2.1/24	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode
PE1(config)#interface eth2	Enter interface mode.
PE1(config-if)#ip address 10.1.3.1/24	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router ospf 1	Set the routing process ID .
PE1(config-router)#ospf router-id 1.1.1.1	Configuring OSPF router-id
PE1(config-router)#network 1.1.1.1/32 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#network 10.1.2.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#network 10.1.3.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#segment-routing mpls	Enable segment routing under router OSPF process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#ip vrf vrf1	Configure VPN Routing/Forwarding instance
PE1(config-vrf)#rd 100:1	route distinguisher
PE1(config-vrf)#route-target both 200:1	route target
PE1(config-vrf)#exit	Exit VRF mode
PE1(config)#interface eth3	Enter interface mode
PE1(config-if)#ip vrf forwarding vrf1	Enable IP VRF forwarding on the interface
PE1(config-if)#ip address 177.1.1.1/24	Configure the IP address for the non-default VRF interface.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#router bgp 100	Configure router BGP in AS 100
PE1(config-router)#neighbor 1.1.1.6 remote-as 100	Configure neighbor in remote-as 100
PE1(config-router)#neighbor 1.1.1.6 update-source lo	Configure neighbor with update-source loopback
PE1(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE1(config-router-af)#neighbor 1.1.1.6 activate	Activate VPNv4 neighbor
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#address-family ipv4 vrf vrf1	Enter address-family VRF
PE1(config-router-af)#redistribute connected	Redistribute all the connected VRF routes
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#exit	Exit router mode

PE1(config)#commit	Commit candidate configuration to be running configuration
PE1(config)#exit	Exit configuration mode

PE1 (Explicit Path Configuration)

The following are the step-by-step configurations on the PE1 router.

PE1(config)#segment-routing	Enter segment-routing mode
PE1(config-sr)#traffic-engineering	Enter segment-routing traffic-engineering mode
PE1(config-sr-te)#segment-list p1-p3-pe2	Configure a segment-list
PE1(config-sr-sl)#index 10 segment-type-1 16002	Configure the segment-list entry with index 10 and label as prefix-sid of P2
PE1(config-sr-sl)#index 20 segment-type-1 16004	Configure the segment-list entry with index 10 and label as prefix-sid of P4
PE1(config-sr-sl)#index 30 segment-type-1 16006	Configure the segment-list entry with index 10 and label as prefix-sid of PE2
PE1(config-sr-sl)#exit-sr-sl	Exit router mode
PE1(config-sr-te)#policy to-pe2	Configure an SR-policy
PE1(config-sr-pol)#color 111 end-point 1.1.1.6	Configure SR-policy with key ie., color and end-point
PE1(config-sr-pol)#candidate-path 1	Configure a candidate-path for the SR-policy
PE1(config-sr-pol-cp)#preference 1000	Configure the preference value for the candidate-path
PE1(config-sr-pol-cp)#explicit segment-list p1-p3-pe2	Configure the candidate-path as explicit-path with segment-list
PE1(config-sr-pol-cp)#exit	Exit segment-routing mode
PE1(config)#exit	Exit configure terminal mode
PE1(config)#commit	Commit candidate configuration to be running configuration

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 1.1.1.2/32 secondary	Configure the IP address of the interface.
P1(config-if)#prefix-sid index 2	Configure prefix sid index value.
P1(config-if)#exit	Exit interface mode.

P1(config)#interface eth1	Enter interface mode.
P1(config-if)#ip address 10.1.2.2/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth2	Enter interface mode.
P1(config-if)#ip address 10.2.4.1/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth3	Enter interface mode.
P1(config-if)#ip address 10.2.3.1/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#router ospf 1	Set the routing process ID .
P1(config-router)#ospf router-id 1.1.1.2	Configure OSPF router-id
P1(config-router)#network 1.1.1.2/32 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.1.2.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.2.3.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.2.4.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)#exit	Exit router mode.
P1(config)#exit	Exit configure terminal mode

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 1.1.1.3/32 secondary	Configure the IP address of the interface.
P2(config-if)#prefix-sid index 3	Configure prefix SID index value.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth2	Enter interface mode.
P2(config-if)#ip address 10.1.3.2/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth1	Enter interface mode.

P2(config-if)#ip address 10.3.5.1/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth3	Enter interface mode.
P2(config-if)#ip address 10.2.3.2/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ospf 1	Set the routing process ID .
P2(config-router)#ospf router-id 1.1.1.3	Configure OSPF router-id
P2(config-router)#network 1.1.1.3/32 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 10.1.3.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 10.2.3.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 10.3.5.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)#exit	Exit router mode.
P2(config)#exit	Exit configure terminal mode
P1(config)#commit	Commit candidate configuration to be running configuration

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface lo	Enter interface mode.
P3(config-if)#ip address 1.1.1.4/32 secondary	Configure the IP address of the interface.
P3(config-if)#prefix-sid index 4	Configure prefix SID index value.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)#ip address 10.2.4.2/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth3	Enter interface mode.
P3(config-if)#ip address 10.4.5.1/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.

P3(config)#interface eth1	Enter interface mode.
P3(config-if)#ip address 10.4.6.1/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#router ospf 1	Set the routing process ID .
P3(config-router)#ospf router-id 1.1.1.4	Configure OSPF router-id
P3(config-router)#network 1.1.1.4/32 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 10.2.4.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 10.4.5.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 10.4.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#segment-routing mpls	Enable segment routing under router process.
P3(config-router)#exit	Exit router mode.
P3(config)#exit	Exit configure terminal mode
P3(config)#commit	Commit candidate configuration to be running configuration

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface lo	Enter interface mode.
P4(config-if)#ip address 1.1.1.5/32 secondary	Configure the IP address of the interface.
P4(config-if)#prefix-sid index 5	Configure prefix sid index value.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)#ip address 10.3.5.2/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth3	Enter interface mode.
P4(config-if)#ip address 10.4.5.2/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)#ip address 10.5.6.1/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.

P4(config-if)#exit	Exit interface mode.
P4(config)#router ospf 1	Set the routing process ID .
P4(config-router)#ospf router-id 1.1.1.5	Configure OSPF router-id
P4(config-router)#network 1.1.1.5/32 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#network 10.3.5.0/24 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#network 10.4.5.0/24 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#network 10.5.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#segment-routing mpls	Enable segment routing under router process.
P4(config-router)#exit	Exit router mode.
P4(config)#exit	Exit configure terminal mode
P4(config)#commit	Commit candidate configuration to be running configuration

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 1.1.1.6/32 secondary	Configure the IP address of the interface.
PE2(config-if)#prefix-sid index 6	Configure prefix SID index value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth1	Enter interface mode.
PE2(config-if)#ip address 10.4.6.2/24	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode
PE2(config)#interface eth2	Enter interface mode.
PE2(config-if)#ip address 10.5.6.2/24	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router ospf 1	Set the routing process ID .
PE2(config-router)#ospf router-id 1.1.1.6	Configuring OSPF router-id
PE2(config-router)#network 1.1.1.6/32 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#network 10.4.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#network 10.5.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#segment-routing mpls	Enable segment routing under router OSPF process.

PE2(config-router)#exit	Exit router mode.
PE2(config)#ip vrf vrf1	Configure VPN Routing/Forwarding instance
PE2(config-vrf)#rd 100:1	route distinguisher
PE2(config-vrf)#route-target both 200:1	route target
PE2(config)#exit	Exit vrf mode
PE2(config)#interface eth3	Enter interface mode
PE2(config-if)#ip vrf forwarding vrf1	Enable IP VRF forwarding on the interface
PE2(config-if)#ip address 202.1.1.2/24	Configure the IP address of the non-default VRF interface.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router bgp 100	Configure router BGP in AS 100
PE2(config-router)#neighbor 1.1.1.1 remote-as 100	Configure neighbor in remote-as 100
PE2(config-router)#neighbor 1.1.1.1 update-source lo	Configure neighbor with update-source loopback
PE2(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE2(config-router-af)#neighbor 1.1.1.1 activate	Activate VPNv4 neighbor
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#address-family ipv4 vrf vrf1	Enter address-family VRF
PE2(config-router-af)#redistribute connected	Redistribute all the connected VRF routes
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#exit	Exit router mode
PE2(config)#exit	Exit router mode
PE2(config)#commit	Commit candidate configuration to be running configuration
PE2(config)#exit	Exit configuration mode

Validation

Validation 1

Verify IP OSPF Neighbor

```
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
1.1.1.2	1	Full/Backup	00:00:38	10.1.2.2	eth1	0
1.1.1.3	1	Full/Backup	00:00:38	10.1.3.2	eth2	0

```
PE1#
```


Validation 2

Verify Segment-Routing Policy

```

PE1#show segment-routing policy
Policy                               Color      End-point    State      Forwarding-Info
to-pe2                              111        1.1.1.6      UP          3/16004/16006/eth1

PE1#show segment-routing policy detail
Policy-Name: to-pe2    Color 111    End-point 1.1.1.6      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:08:05
State Transition Count: 1
CSPF Retry Limit: 100    CSPF Retry Interval: 10
Binding SID :
BSID: 25600
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 1000    Path Type: Explicit    CP Origin: Local
Segment List:
Total no. of segments: 3
Segment0[LABEL]: Label :16002
Segment1[LABEL]: Label :16004
Segment2[LABEL]: Label :16006
Out-if: eth1        Out-label-stack: 3/16004/16006
Attributes:
Configured:
Explicit segment-list Name: p1-p3-pe2

PE1#show segment-routing policy candidate-path origin local

Policy-Name                               Color      End-
point      State      Forwarding-Info
to-
pe2                               111        1.1.1.6      UP
3/16004/16006/eth1
CP ID: 1, Active
Preference: 1000    Path Type: Explicit    CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 3
Segment0[LABEL]: Label :16002
Segment1[LABEL]: Label :16004
Segment2[LABEL]: Label :16006
Out-if: eth1        Out-label-stack: 3/16004/16006
Attributes:
Configured:
Explicit segment-list Name: p1-p3-pe2

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, UPStr - upstreamILM-ECMP LDP: Disabled, SR: Disabled

Code  FEC/VRF/L2CKT  ILM-ID  In-Label  Out-Label  In-Intf  Out-
Intf/VRF  Nexthop  pri  Algo-Num  UpTime  UPStr peers
O>  1.1.1.5/32    3      16005    16005      N/A      eth2      10.1.3.2
Yes  0            00:07:00
O>  1.1.1.3/32    2      16003    3          N/A      eth2      10.1.3.2
Yes  0            00:08:41
O>  1.1.1.2/32    7      16002    3          N/A      eth1      10.1.2.2
Yes  0            00:01:20
O>  1.1.1.4/32    4      16004    16004      N/A      eth1      10.1.2.2
Yes  0            00:06:51
O>  10.1.3.2/32   1      25600    3          N/A      eth2      10.1.3.2
Yes  0            00:08:48

```

```

O> 1.1.1.6/32 5 16006 16006 N/A eth2 10.1.3.2
Yes 0 00:05:16
16006 16006 N/A eth1 10.1.2.2
Yes - -
P> 1.1.1.6/32 8 24960 16004 N/A eth1 10.1.2.2
Yes N/A 00:01:19
O> 10.1.2.2/32 6 25601 3 N/A eth1 10.1.2.2
Yes 0 00:01:23
PE1#
PE1#
PE1#show mpls ftn-table 1.1.1.6/32
Primary FTN entry with FEC: 1.1.1.6/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: SR_POLICY, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 0
Cross connect ix: 2, 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: eth1, out label: 3\16004\16006
Nexthop addr: 10.1.2.2 cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 1.1.1.6/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 0
Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 11
Owner: OSPF-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 11, owner: OSPF-SR, Stale: NO, out intf: eth2, out label: 16006
Nexthop addr: 10.1.3.2 cross connect ix: 7, op code: Push

PE1#
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, SR: Disabled
Code FEC FTN-ID Nhlfe-ID Tunnel-ID Pri Out-Label Out-
Intf ELC Nexthop Algo-Num UpTime
O> 1.1.1.2/32 5 19 - - - - -
0 00:01:25
17 0 Yes 3 eth1 No 10
.1.2.2 - -
O> 1.1.1.3/32 1 3 - - - - -
0 00:08:46
1 0 Yes 3 eth2 No 10
.1.3.2 - -
O> 1.1.1.4/32 3 23 - - - - -
0 00:06:56
22 0 Yes 16004 eth1 No 10
.1.2.2 - -
O> 1.1.1.5/32 2 5 - - - - -
0 00:07:05
4 0 Yes 16005 eth2 No 10
.1.3.2 - -
P> 1.1.1.6/32 6 21 1 Yes 3 eth1 No 10
.1.2.2 N/A 00:01:24
O> 1.1.1.6/32 4 11 - - - - -
0 00:05:21
10 0 Yes 16006 eth2 No 10
.1.3.2 - -
25 0 Yes 16006 eth1 No 10
.1.2.2 - -
PE1#

```

Validation 3**Verify VPNV4 all summary.**

```

PE1#show ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 2
1 BGP AS-PATH entries
0 BGP community entries

Neighbor          V    AS  MsgRcv   MsgSen TblVer   InQ   OutQ   Up/Down   State/PfxRcd
1.1.1.6            4    100    94      97      2       0     0   00:38:50         1

Total number of neighbors 1

Total number of Established sessions 1
PE1#

PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 2
Primary FTN entry with FEC: 202.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, Color: 111
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 12
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 12, owner: BGP, Stale: NO, BGP out intf: xe7, transport out intf:
xe7, out label: 24960
Nexthop addr: 1.1.1.6      cross connect ix: 8, op code: Push and Lookup

```

Topology-Independent Loop-Free Alternate

The term topology independent (TI) refers to the ability to provide a loop free backup path irrespective of the topologies used in the network. Topology-Independent Loop-Free Alternate (TI-LFA) uses segment routing to provide link, node and Shared Risk Link Groups (SRLG) protection in topologies where other fast reroute techniques, such as RLFA (Remote Loop Free Alternative) cannot provide protection.

The goal of TI-LFA is to reduce the packet loss that results while routers converge after a topology change due to a link failure. Rapid failure repair (up to 50msec) is achieved using pre-calculated backup paths that are loop-free.

Terminology

PLR : Point of Local Repair : The node that is just upstream of the protected resource. This node notices that the protected resource(link/node/set-of-links) is broken first and uses an FRR mechanism to protect that resource

Repair Node : The node to which the PLR wants to get the traffic to during the convergence period, once the protected resource fails, because the repair node is guaranteed to have a path to the destination 'D'

Pre-Convergence State : A source 'S' is said to be in a pre-convergence state regarding a particular destination 'D' from the time the primary-path to 'D' fails until 'S' installs a new route to 'D'

Post-Convergence State : A source 'S' is said to be in a post-convergence state regarding a particular destination 'D' after it installs a new route to 'D'

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 from that set of routers the router reachable over the protected link. 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: The Q-space of a router with respect to a protected link is the set of routers from which that specific router can be reached without any path (including equal-cost path 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.

Difference between LFA/RLFA/TI-LFA

LFA :

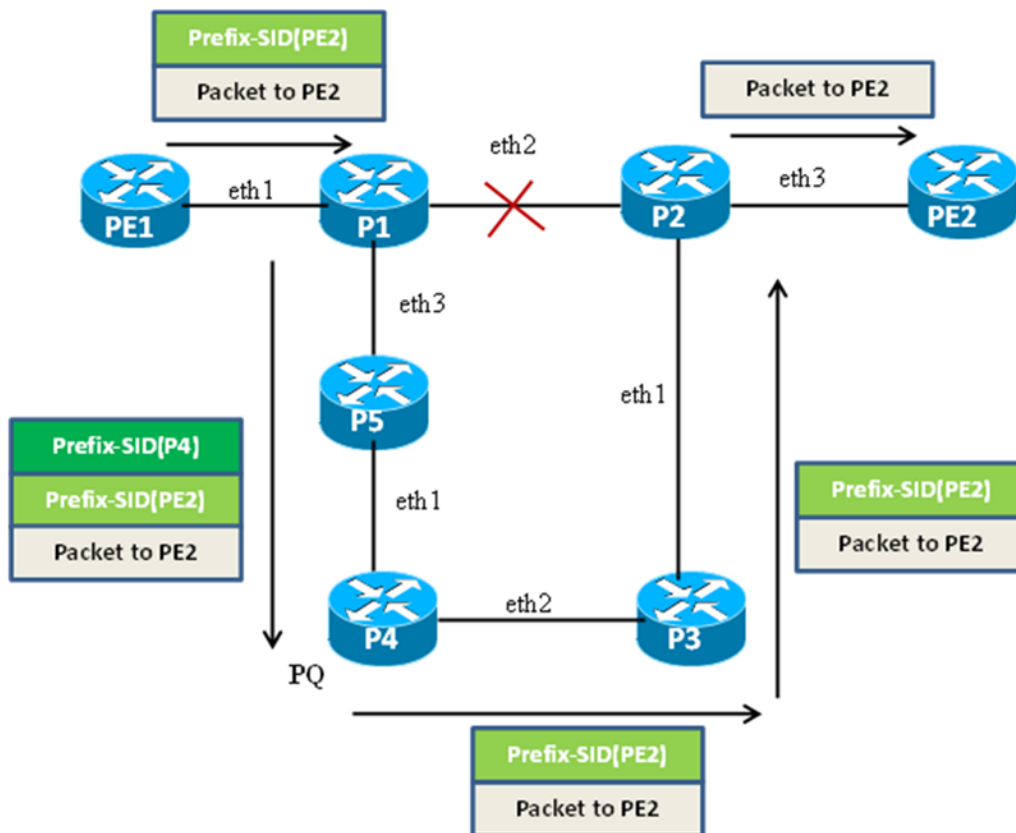
- The repair node is restricted to be the neighbor of the PLR

RLFA :

- The repair node is not restricted to be the direct neighbor of the PLR. It can be a node from the PQ-space.
- A repair tunnel would be created from the PLR to the repair node and this repair tunnel traverses the IGP shortest-path from the PLR to the repair node
- The repair tunnel can be LDP-signalled(Targeted LDP session required from the PLR to the repair node)

TI-LFA:

- SR-paths can be used as repair tunnels. Because the repair tunnel is an SR-path, it is not required to traverse the IGP shortest-path from the PLR to the repair node. It can be any viable path that can be specified by the PLR as an ordered list of segments.
- Thus, the repair node can be outside of the PLR's P-space.
- However, the repair node must be within the destination node's Q-space. Sometimes, the repair node is also the destination node.
- No TLDP session required in case of TI-LFA as TI-LFA uses segment-routing thus eliminating the overhead of maintaining any state

Topology**Figure 24. TI-LFA FRR path using a PQ Node****Notes:**

- It should be ensured that prefix SIDs are unique globally.
- By default, the CSPF retry limit is 10 times and the CSPF retry interval is 10 seconds. If a policy does not come up within 100 seconds, it will require operator intervention.

TI-LFA FRR Path using a PQ node with OSPF-SR Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

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 the IP address of the interface.
PE1(config-if)#prefix-sid index 1	Configure prefix SID index value.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.
PE1(config-if)#ip address 10.1.2.1/32	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode
PE1(config)#router ospf 100	Set the routing process ID .
PE1(config-router)#ospf router-id 1.1.1.1	Configuring OSPF router-id
PE1(config-router)#network 1.1.1.1/32 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#network 10.1.2.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE1(config-router)#segment-routing mpls	Enable segment routing under router process.
PE1(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0
PE1(config-router)#exit	Exit router mode.
PE1(config)#exit	Exit configure mode
PE1(config)#commit	Commit the candidate configuration to the running configuration.

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 1.1.1.2/32 secondary	Configure the IP address of the interface.
P1(config-if)#prefix-sid index 2	Configure prefix SID index value.
P1(config-if)#exit	Exit interface mode.

P1(config)#interface eth1	Enter interface mode.
P1(config-if)#ip address 10.1.2.2/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth2	Enter interface mode.
P1(config-if)#ip address 10.2.3.1/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth3	Enter interface mode.
P1(config-if)#ip address 10.2.6.1/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#router ospf 100	Set the routing process ID .
P1(config-router)#ospf router-id 1.1.1.2/32 secondary	Configure OSPF router-id
P1(config-router)#network 1.1.1.2/32 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.1.2.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.2.3.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.2.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0
P1(config-router)#exit	Exit router mode.
P1(config)#exit	Exit configure mode
P1(config)#commit	Commit the candidate configuration to the running configuration.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 1.1.1.3/32 secondary	Configure the IP address of the interface.
P2(config-if)#prefix-sid index 3	Configure prefix SID index value.
P2(config-if)#exit	Exit interface mode.

P2(config)#interface eth1	Enter interface mode.
P2(config-if)#ip address 10.3.4.1/24 secondary	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth2	Enter interface mode.
P2(config-if)#ip address 10.2.3.2/24 secondary	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth3	Enter interface mode.
P2(config-if)#ip address 10.3.7.1/24 secondary	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#router ospf 100	Set the routing process ID .
P2(config-router)#ospf router-id 1.41.1.3/24	Configure OSPF router-id
P2(config-router)#network 1.1.1.3/32 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 10.3.4.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 10.2.3.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#network 10.3.7.0/24 area 0.0.0.0	Configure OSPF network in area 0
P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0.
P2(config-router)#exit	Exit router mode.
P2(config)#exit	Exit configure mode
P2(config)#commit	Commit the candidate configuration to the running configuration.

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface lo	Enter interface mode.
P3(config-if)#ip address 1.1.1.4/32 secondary	Configure the IP address of the interface.
P3(config-if)#prefix-sid index 4	Configure prefix SID index value.

P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth1	Enter interface mode.
P3(config-if)#ip address 10.3.4.2/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)#ip address 10.4.5.1/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#router ospf 100	Set the routing process ID .
P3(config-router)#ospf router-id 1.1.1.4/32 secondary	Configure OSPF router-id
P3(config-router)#network 1.1.1.4/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 10.3.4.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#network 10.4.5.0/24 area 0.0.0.0	Configure OSPF network in area 0
P3(config-router)#segment-routing mpls	Enable segment routing under router process.
P3(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0.
P3(config-router)#exit	Exit router mode.
P3(config)#exit	Exit configure mode
P3(config)#commit	Commit the candidate configuration to the running configuration.

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface lo	Enter interface mode.
P4(config-if)#ip address 1.1.1.5/32 secondary	Configure the IP address of the interface.
P4(config-if)#prefix-sid index 5	Configure prefix SID index value.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)#ip address 10.5.6.1/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.

P4(config)#interface eth2	Enter interface mode.
P4(config-if)#ip address 10.4.5.2/24	Configure the IP address of the interface.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#router ospf 100	Set the routing process ID .
P4(config-router)#ospf router-id 1.1.1.5/24	Configure OSPF router-id
P4(config-router)#network 1.1.1.5/32 area 0.0.0.0 secondary	Configure OSPF network in area 0
P4(config-router)#network 10.4.5.0/24 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#network 10.5.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P4(config-router)#segment-routing mpls	Enable segment routing under router process.
P4(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0.
P4(config-router)#exit	Exit router mode.
P4(config)#exit	Exit configure mode
P4(config)#commit	Commit the candidate configuration to the running configuration.

P5

The following are the step-by-step configurations on the P5 router.

P5#configure terminal	Enter configure mode.
P5(config)#interface lo	Enter interface mode.
P5(config-if)#ip address 1.1.1.6/32 secondary	Configure the IP address of the interface.
P5(config-if)#prefix-sid index 6	Configure prefix SID index value.
P5(config-if)#exit	Exit interface mode.
P5(config)#interface eth1	Enter interface mode.
P5(config-if)#ip address 10.5.6.2/24	Configure the IP address of the interface.
P5(config-if)#label-switching	Enable label switching.
P5(config-if)#exit	Exit interface mode.
P5(config)#interface eth3	Enter interface mode.
P5(config-if)#ip address 10.2.6.2/24	Configure the IP address of the interface.
P5(config-if)#label-switching	Enable label switching.
P5(config-if)#exit	Exit interface mode.
P5(config)#router ospf 100	Set the routing process ID .

P5(config-router)#ospf router-id 1.1.1.6/24	Configure OSPF router-id
P5(config-router)#network 1.1.1.6/24 area 0.0.0.0	Configure OSPF network in area 0
P5(config-router)#network 10.2.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P5(config-router)#network 10.5.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P5(config-router)#segment-routing mpls	Enable segment routing under router process.
P5(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0.
P5(config-router)#exit	Exit router mode.
P5(config)#exit	Exit configure mode
P5(config)#commit	Commit the candidate configuration to the running configuration.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 1.1.1.7/32 secondary	Configure the IP address of the interface.
PE2(config-if)#prefix-sid index 7	Configure prefix SID index value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth3	Enter interface mode.
PE2(config-if)#ip address 10.3.7.2/24	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router ospf 100	Set the routing process ID .
PE2(config-router)#ospf router-id 1.1.1.7/32	Configuring OSPF router-id
PE2(config-router)#network 1.1.1.7/24 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#network 10.3.7.0/24 area 0.0.0.0	Configure OSPF network in area 0
PE2(config-router)#segment-routing mpls	Enable segment routing under router OSPF process.
PE2(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0.
PE2(config-router)#exit	Exit router mode.
PE2(config)#exit	Exit configure mode
PE2(config)#commit	Commit the candidate configuration to the running configuration.

Validation

Validation 1

Verify OSPF adjacencies on P1

```
P1#show ip ospf neighbor
```

```
Total number of full neighbors: 3
```

```
OSPF process 100 VRF(default):
```

Neighbor ID	Pri	State	Dead Time	Address	Interface	Instance
1.1.1.1	1	Full/DR	00:00:32	10.1.2.1	eth1	0
1.1.1.3	1	Full/Backup	00:00:33	10.2.3.2	eth2	0
1.1.1.6	1	Full/Backup	00:00:33	10.2.6.2	eth3	0

Validation 2

P1

Verify that the 2 PQ nodes for PE2 (1.1.1.7/32)

```
P1#show ip ospf tilfa-backup-path
```

```
OSPF process 100:
```

```
Route [1.1.1.1]
```

```
Primary Path Nexthop : 10.1.2.1, eth1
```

```
No PQ node
```

```
Route [1.1.1.3]
```

```
Primary Path Nexthop : 10.2.3.2, eth2
```

```
PQ-node: 1.1.1.5
```

```
Protection Type : Node Protecting
```

```
Route [1.1.1.4]
```

```
Primary Path Nexthop : 10.2.3.2, eth2
```

```
PQ-node: 1.1.1.5
```

```
Protection Type : Node Protecting
```

```
Route [1.1.1.5]
```

```
Primary Path Nexthop : 10.2.6.2, eth3
```

```
PQ-node: 1.1.1.4
```

```
Protection Type : Node Protecting
```

```
Route [1.1.1.6]
```

```
Primary Path Nexthop : 10.2.6.2, eth3
```

```
PQ-node: 1.1.1.4
```

```
Protection Type : Node Protecting
```

```
Route [1.1.1.7]
```

```
Primary Path Nexthop : 10.2.3.2, eth2
```

```
PQ-node: 1.1.1.5
```

```
Protection Type : Node Protecting
```

```
Neighbor [1.1.1.1]
```

```
Neighbor [1.1.1.3]
```

```
PQ-node: 1.1.1.5
```

```
Neighbor [1.1.1.6]
```

```
PQ-node: 1.1.1.4
```

```
Displaying vertex-info in tilfa_network table
```

```
Vertex [1.1.1.1]
```

```
Interface: eth1
```

```
P node: 1.1.1.4 dist: 2
```

```
P node: 1.1.1.5 dist: 2
```

```
P node: 1.1.1.7 dist: 2
```

```
P node: 1.1.1.3 dist: 1
```

```
P node: 1.1.1.6 dist: 1
P node (Node Protection): 1.1.1.4 dist: 2
P node (Node Protection): 1.1.1.5 dist: 2
P node (Node Protection): 1.1.1.6 dist: 1
P node (Node Protection): 1.1.1.7 dist: 2
P node (Node Protection): 1.1.1.3 dist: 1
Q node: 1.1.1.1
No PQ node

Vertex [1.1.1.2]

Vertex [1.1.1.3]
  Interface: eth2
    P node: 1.1.1.1 dist: 1
    P node: 1.1.1.4 dist: 2
    P node: 1.1.1.5 dist: 2
    P node: 1.1.1.6 dist: 1
    P node (Node Protection): 1.1.1.5 dist: 2
    P node (Node Protection): 1.1.1.6 dist: 1
    P node (Node Protection): 1.1.1.1 dist: 1
    P node (Node Protection): 1.1.1.4 dist: 2
    Q node: 1.1.1.3
    Q node: 1.1.1.4
    Q node: 1.1.1.5
    Q node: 1.1.1.7
    PQ-node: 1.1.1.5
    Backup out-interface: eth3
    PQ-node (Node Protection): 1.1.1.5
    Backup out-interface (Node Protection): eth3

Vertex [1.1.1.4]
  Interface: eth2
    P node: 1.1.1.1 dist: 1
    P node: 1.1.1.4 dist: 2
    P node: 1.1.1.5 dist: 2
    P node: 1.1.1.6 dist: 1
    P node (Node Protection): 1.1.1.5 dist: 2
    P node (Node Protection): 1.1.1.6 dist: 1
    P node (Node Protection): 1.1.1.1 dist: 1
    P node (Node Protection): 1.1.1.4 dist: 2
    Q node: 1.1.1.3
    Q node: 1.1.1.4
    Q node: 1.1.1.5
    Q node: 1.1.1.7
    PQ-node: 1.1.1.5
    Backup out-interface: eth3
    PQ-node (Node Protection): 1.1.1.5
    Backup out-interface (Node Protection): eth3

Vertex [1.1.1.5]
  Interface: eth3
    P node: 1.1.1.1 dist: 1
    P node: 1.1.1.4 dist: 2
    P node: 1.1.1.5 dist: 2
    P node: 1.1.1.7 dist: 2
    P node: 1.1.1.3 dist: 1
    P node (Node Protection): 1.1.1.3 dist: 1
    P node (Node Protection): 1.1.1.4 dist: 2
    P node (Node Protection): 1.1.1.7 dist: 2
    P node (Node Protection): 1.1.1.1 dist: 1
    P node (Node Protection): 1.1.1.5 dist: 2
    Q node: 1.1.1.4
    Q node: 1.1.1.5
    Q node: 1.1.1.6
    PQ-node: 1.1.1.4
    Backup out-interface: eth2
    PQ-node (Node Protection): 1.1.1.4
    Backup out-interface (Node Protection): eth2
```

```

Vertex [1.1.1.6]
Interface: eth3
  P node: 1.1.1.1 dist: 1
  P node: 1.1.1.4 dist: 2
  P node: 1.1.1.5 dist: 2
  P node: 1.1.1.7 dist: 2
  P node: 1.1.1.3 dist: 1
  P node (Node Protection): 1.1.1.3 dist: 1
  P node (Node Protection): 1.1.1.4 dist: 2
  P node (Node Protection): 1.1.1.7 dist: 2
  P node (Node Protection): 1.1.1.1 dist: 1
  P node (Node Protection): 1.1.1.5 dist: 2
  Q node: 1.1.1.4
  Q node: 1.1.1.5
  Q node: 1.1.1.6
  PQ-node: 1.1.1.4
  Backup out-interface: eth2
  PQ-node (Node Protection): 1.1.1.4
  Backup out-interface (Node Protection): eth2

Vertex [1.1.1.7]
Interface: eth2
  P node: 1.1.1.1 dist: 1
  P node: 1.1.1.4 dist: 2
  P node: 1.1.1.5 dist: 2
  P node: 1.1.1.6 dist: 1
  P node (Node Protection): 1.1.1.5 dist: 2
  P node (Node Protection): 1.1.1.6 dist: 1
  P node (Node Protection): 1.1.1.1 dist: 1
  P node (Node Protection): 1.1.1.4 dist: 2
  Q node: 1.1.1.3
  Q node: 1.1.1.4
  Q node: 1.1.1.5
  Q node: 1.1.1.7
  PQ-node: 1.1.1.5
  Backup out-interface: eth3
  PQ-node (Node Protection): 1.1.1.5
  Backup out-interface (Node Protection): eth3

P1#
P1#show ip ospf tilfa-repair-list

1.1.1.1/32
  Primary Path Metric    :2
  Route ftnix:8 ilmix:9
  SR Incoming Label      : 16001
  Primary Path Nexthop    : 10.1.2.1, eth1
  SR outgoing Label      : 3
  No PQ node

1.1.1.2/32
  Primary Path Metric    :1
1.1.1.3/32
  Primary Path Metric    :2
  Route ftnix:1 ilmix:1
  SR Incoming Label      : 16003
  Primary Path Nexthop    : 10.2.3.2, eth2
  SR outgoing Label      : 3
  PQ-node: 1.1.1.5
  Backup outgoing Label   : 16003
  Bypass_trunk id :103
  Backup out interface: eth3
  Protection Type         : Node Protecting

1.1.1.4/32
  Primary Path Metric    :3
  Route ftnix:2 ilmix:2

```

```
SR Incoming Label    : 16004
Primary Path Nexthop  : 10.2.3.2, eth2
SR outgoing Label    : 16004
PQ-node: 1.1.1.5
Backup outgoing Label : 16004
Bypass_trunk id :103
Backup out interface: eth3
Protection Type       : Node Protecting

Bypass-Trunk: 104 Name: 1.1.1.4_nexthop__10016 ftn_ix:10
ftn_info->trunk_ftn_ix : 10, ref_cnt : 3
Number Of outgoing label: 1
Outgoing labels:
  label 1: 16004
Nexthop address: 10.2.3.2

1.1.1.5/32
Primary Path Metric   :3
Route ftnix:3 ilmix:3
SR Incoming Label     : 16005
Primary Path Nexthop   : 10.2.6.2, eth3
SR outgoing Label     : 16005
PQ-node: 1.1.1.4
Backup outgoing Label  : 16005
Bypass_trunk id :104
Backup out interface: eth2
Protection Type        : Node Protecting

Bypass-Trunk: 103 Name: 1.1.1.5_nexthop__10023 ftn_ix:9
ftn_info->trunk_ftn_ix : 9, ref_cnt : 4
Number Of outgoing label: 1
Outgoing labels:
  label 1: 16005
Nexthop address: 10.2.6.2

1.1.1.6/32
Primary Path Metric   :2
Route ftnix:4 ilmix:4
SR Incoming Label     : 16006
Primary Path Nexthop   : 10.2.6.2, eth3
SR outgoing Label     : 3
PQ-node: 1.1.1.4
Backup outgoing Label  : 16006
Bypass_trunk id :104
Backup out interface: eth2
Protection Type        : Node Protecting

1.1.1.7/32
Primary Path Metric   :3
Route ftnix:5 ilmix:5
SR Incoming Label     : 16007
Primary Path Nexthop   : 10.2.3.2, eth2
SR outgoing Label     : 16007
PQ-node: 1.1.1.5
Backup outgoing Label  : 16007
Bypass_trunk id :103
Backup out interface: eth3
Protection Type        : Node Protecting

10.1.2.0/24
Primary Path Metric   :1
10.2.3.0/24
Primary Path Metric   :1
10.2.6.0/24
Primary Path Metric   :1
10.3.4.0/24
Primary Path Metric   :2
10.3.7.0/24
```

```

Primary Path Metric :2
10.4.5.0/24
Primary Path Metric :3
10.5.6.0/24
Primary Path Metric :2
P1#
P1#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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-
Intf/VRF Nexthop pri Algo-Num UpTime UPStr peers
O> 1.1.1.6/32 4 16006 3 N/A eth3 10.2
.6.2 Yes 0 00:09:20 16006 16006 N/A eth2 10.2
.3.2 No - - - - - -
O> 1.1.1.4/32 2 16004 16004 N/A eth2 10.2
.3.2 Yes 0 00:09:20 16004 16004 N/A eth3 10.2
.6.2 No - - - - - -
O> 1.1.1.3/32 1 16003 3 N/A eth2 10.2
.3.2 Yes 0 00:09:20 16003 16003 N/A eth3 10.2
.6.2 No - - - - - -
O> 1.1.1.1/32 9 16001 3 N/A eth1 10.1.
2.1 Yes 0 00:09:11 16005 16005 N/A eth3 10.2
O> 1.1.1.5/32 3 16005 16005 N/A eth2 10.2
.6.2 Yes 0 00:09:20 16005 16005 N/A eth2 10.2
.3.2 No - - - - - -
O> 10.2.3.2/32 6 24320 3 N/A eth2 10.2
.3.2 Yes 0 00:09:20 24320 16003 N/A eth3 10.2
.6.2 No - - - - - -
O> 1.1.1.7/32 5 16007 16007 N/A eth2 10.2
.3.2 Yes 0 00:09:20 16007 16007 N/A eth3 10.2
.6.2 No - - - - - -
O> 10.2.6.2/32 7 24321 3 N/A eth3 10.2
.6.2 Yes 0 00:09:20 24321 16006 N/A eth2 10.2
.3.2 No - - - - - -
O> 10.1.2.1/32 8 24322 3 N/A eth1 10.1.
2.1 Yes 0 00:09:18

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, SR: Disabled
Code FEC FTN-ID Nhlfe-ID Tunnel-ID Pri Out-Label Out-
Intf ELC Nexthop Algo-Num UpTime
O> 1.1.1.1/32 8 91 - - - -
- 0 00:09:40 13 0 Yes 3 eth1 No
10.1.2.1 - - - - - -
O> 1.1.1.3/32 1 19 - - - -
- 0 00:09:49 4 0 Yes 3 eth2 No
10.2.3.2 - - - - -

```



```

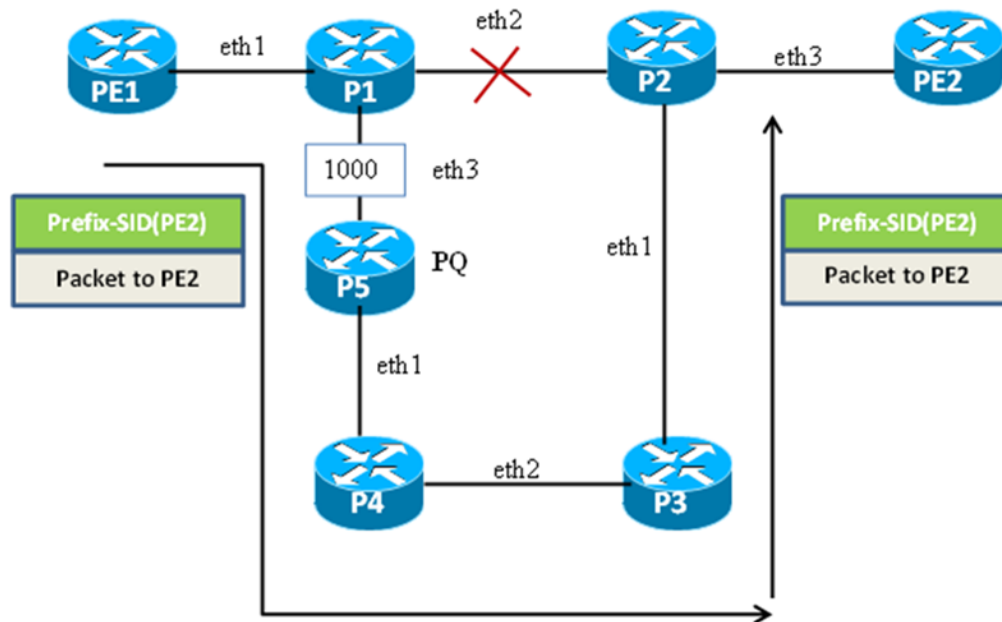
          No      16003      eth3      92      -      10.2.6.2      -      -
O>  1.1.1.4/32      2      22      -      -      -      -
    -      0      00:09:49      7      0      Yes      16004      eth2      No
    10.2.3.2      -      -      21      -
          No      16004      eth3      No      10.2.6.2      -      -
O  (b)>  1.1.1.4/32      10      7      104      Yes      16004      eth2      No
    10.2.3.2      0      00:09:18
O>  1.1.1.5/32      3      24      -      -      -      -
    -      0      00:09:49      16      0      Yes      16005      eth3      No
    10.2.6.2      -      -      89      -
          No      16005      eth2      No      10.2.3.2      -      -
O  (b)>  1.1.1.5/32      9      16      103      Yes      16005      eth3      No
    10.2.6.2      0      00:09:18
O>  1.1.1.6/32      4      26      -      -      -      -
    -      0      00:09:49      1      0      Yes      3      eth3      No
    10.2.6.2      -      -      94      -
          No      16006      eth2      No      10.2.3.2      -      -
O>  1.1.1.7/32      5      29      -      -      -      -
    -      0      00:09:49      10      0      Yes      16007      eth2      No
    10.2.3.2      -      -      28      -
          No      16007      eth3      No      10.2.6.2      -      -

```

TI-LFA FRR Path using a PQ node with ISIS-SR Configuration

Topology

Figure 25. TI-LFA FRR path using a PQ Node that is a Direct Neighbor



PE1

The following are the step-by-step configurations on the PE1 router.

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 the IP address of the interface.
PE1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#prefix-sid index 1	Configure prefix SID index value.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.
PE1(config-if)#ip address 10.1.2.1/24	Configure the IP address of the interface.
PE1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config)#router isis 1	Set the routing process ID.
PE1(config-router)#metric-style wide	Configure metric style as wide.

PE1(config-router)#net 49.0000.0000.0000.0001.00	Configure network entity title (NET).
PE1(config-router)#mpls traffic-eng router-id 1.1.1.1	Enable MPLS Traffic Engineering under router process.
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1
PE1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
PE1(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1
PE1(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-2
PE1(config-router)#capability cspf	Enable cspf capability under ISIS 1 process
PE1(config-router)#segment-routing mpls	Enable segment routing under router ISIS process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#exit	Exit configure mode

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 1.1.1.2/32 secondary	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#prefix-sid index 2	Configure prefix SID index value.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth1	Enter interface mode.
P1(config-if)#ip address 10.1.2.2/24	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth2	Enter interface mode.
P1(config-if)#ip address 10.2.3.1/24	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#interface eth3	Enter interface mode.

P1(config-if)#ip address 10.2.6.1/24	Configure the IP address of the interface.
P1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#router isis 1	Set the routing process ID .
P1(config-router)#metric-style wide	Configure metric style as wide.
P1(config-router)#net 49.0000.0000.0000.0002.00	Configure Network entity title (NET).
P1(config-router)#mpls traffic-eng router-id 1.1.1.2	Enable MPLS Traffic Engineering under router process.
P1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P1(config-router)#capability cspf	Enable cspf capability under ISIS 1 process.
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)# fast-reroute ti-lfa level-1 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1
P1(config-router)# fast-reroute ti-lfa level-2 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-2
P1(config-router)#exit	Exit router mode.
P1(config)#exit	Exit configure mode

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 1.1.1.3/32 secondary	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#prefix-sid index 3	Configure prefix SID index value.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth1	Enter interface mode.
P2(config-if)#ip address 10.3.4.1/24	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth2	Enter interface mode.

P2(config-if)#ip address 10.2.3.2/24	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface eth3	Enter interface mode.
P2(config-if)#ip address 10.3.7.1/24	Configure the IP address of the interface.
P2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#router isis 1	Set the routing process ID .
P2(config-router)#metric-style wide	Configure metric style as wide.
P2(config-router)#net 49.0000.0000.0000.0003.00	Configure Network entity title (NET).
P2(config-router)#mpls traffic-eng router-id 1.1.1.3	Enable MPLS Traffic Engineering under router process.
P2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
P2(config)#router isis 1	Set the routing process ID .
P2(config-router)#metric-style wide	Configure metric style as wide.
P2(config-router)#net 49.0001.0000.0000.0003.00	Configure Network entity title (NET).
P2(config-router)# fast-reroute ti-lfa level-1 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1
P2(config-router)# fast-reroute ti-lfa level-2 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1
P2(config-router)#capability cspf	Enable cspf capability under ISIS 1 process
P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)#exit	Exit router mode.

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface lo	Enter interface mode.
P3(config-if)#ip address 1.1.1.4/32 secondary	Configure the IP address of the interface.
P3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#prefix-sid index 4	Configure prefix SID index value.

P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth1	Enter interface mode.
P3(config-if)#ip address 10.3.4.2/24	Configure the IP address of the interface.
P3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)#ip address 10.4.5.1/24	Configure the IP address of the interface.
P3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#router isis 1	Set the routing process ID .
P3(config-router)#metric-style wide	Configure metric style as wide.
P3(config-router)#net 49.0000.0000.0000.0004.00	Configure Network entity title (NET).
P3(config-router)#mpls traffic-eng router-id 1.1.1.4	Enable MPLS Traffic Engineering under router process.
P3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P3(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P3(config-router)# fast-reroute ti-lfa level-1 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1.
P3(config-router)# fast-reroute ti-lfa level-2 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-2.
P3(config-router)#capability cspf	Enable cspf capability under ISIS 1 process
P3(config-router)#metric-style wide	Configure metric style as wide.
P3(config-router)#net 49.0000.0000.0000.0004.00	Configure Network entity title (NET).
P3(config-router)#segment-routing mpls	Enable segment routing under router process.
P3(config-router)#exit	Exit router mode.

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface lo	Enter interface mode.
P4(config-if)#ip address 1.1.1.5/32	Configure the IP address of the interface.
P4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

P4(config-if)#prefix-sid index 5	Configure prefix SID index value.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)#ip address 10.5.6.1/24	Configure the IP address of the interface.
P4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)#ip address 10.4.5.2/24	Configure the IP address of the interface.
P4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#router isis 1	Set the routing process ID .
P4(config-router)#metric-style wide	Configure metric style as wide.
P4(config-router)#net 49.0000.0000.0000.0005.00	Configure Network entity title (NET).
P4(config-router)#mpls traffic-eng router-id 1.1.1.5	Enable MPLS Traffic Engineering under router process.
P4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P4(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P4(config-router)# fast-reroute ti-lfa level-1 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1
P4(config-router)# fast-reroute ti-lfa level-2 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-2
P4(config-router)#capability cspf	Enable cspf capability under ISIS 1 process
P4(config-router)#segment-routing mpls	Enable segment routing under router process.
P4(config-router)#exit	Exit router mode.

P5

The following are the step-by-step configurations on the P5 router.

P5#configure terminal	Enter configure mode.
P5(config)#interface lo	Enter interface mode.
P5(config-if)#ip address 1.1.1.6/32 secondary	Configure the IP address of the interface.
P5(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P5(config-if)#prefix-sid index 6	Configure prefix SID index value.

P5(config-if)#exit	Exit interface mode.
P5(config)#interface eth1	Enter interface mode.
P5(config-if)#ip address 10.5.6.2/24	Configure the IP address of the interface.
P5(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P5(config-if)#label-switching	Enable label switching.
P5(config-if)#exit	Exit interface mode.
P5(config)#interface eth3	Enter interface mode.
P5(config-if)#ip address 10.2.6.2/24	Configure the IP address of the interface.
P5(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
P5(config-if)#label-switching	Enable label switching.
P5(config-if)#exit	Exit interface mode.
P5(config)#router isis 1	Set the routing process ID .
P5(config-router)#metric-style wide	Configure metric style as wide.
P5(config-router)#net 49.0000.0000.0000.0006.00	Configure Network entity title (NET).
P5(config-router)#mpls traffic-eng router-id 1.1.1.6	Enable MPLS Traffic Engineering under router process.
P5(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P5(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P5(config-router)# fast-reroute ti-lfa level-1 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1.
P5(config-router)# fast-reroute ti-lfa level-2 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-2.
P5(config-router)#capability cspf	Enable cspf capability under ISIS 1 process
P5(config-router)#segment-routing mpls	Enable segment routing under router process.
P5(config-router)#exit	Exit router mode.
P5(config)#commit	Commit the candidate configuration to the running configuration.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 1.1.1.7/32 secondary	Configure the IP address of the interface.
PE2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

PE2(config-if)#prefix-sid index 7	Configure prefix SID index value.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth3	Enter interface mode.
PE2(config-if)#ip address 10.3.7.2/24	Configure the IP address of the interface.
PE2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#router isis 1	Set the routing process ID .
PE2(config-router)#metric-style wide	Configure metric style as wide.
PE2(config-router)#net 49.0000.0000.0000.0007.00	Configure Network entity title (NET).
PE2(config-router)#mpls traffic-eng router-id 1.1.1.7	Enable MPLS Traffic Engineering under router process.
PE2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE2(config-router)# fast-reroute ti-lfa level-1 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1
PE2(config-router)# fast-reroute ti-lfa level-2 proto ipv4	Enable per-prefix TI-LFA FRR computation for ISIS level-1
PE2(config-router)#capability cspf	Enable cspf capability under ISIS 1 process
PE2(config-router)#segment-routing mpls	Enable segment routing under router process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration.

Validation

Validation 1

P1

```
P1#show clns is-neighbors
```

```
Tag 1: VRF : default
System Id      Interface  State  Type  Priority  Circuit Id
0000.0000.0003 eth2      Up     L1    64       0000.0000.0003.01
               eth2      Up     L2    64       0000.0000.0003.01
0000.0000.0006 eth3      Up     L1    64       0000.0000.0006.03
               eth3      Up     L2    64       0000.0000.0006.03
0000.0000.0001 eth1      Up     L1    64       0000.0000.0001.02
               eth1      Up     L2    64       0000.0000.0001.02
```

```
P1#
```

```
P1#show isis tilfa pq
```

Tag 1: Level-1 Link State Database:

Node: 0000.0000.0001.00-00

Interface eth1

P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0001
NO SRLG Protecting P Nodes

Node Protecting P Nodes

P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path

No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0003.00-00

Interface eth2

P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes

P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

PQ Node: 0000.0000.0005.00-00 backup dist:20

No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0004.00-00

Interface eth2

P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes

P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

PQ Node: 0000.0000.0005.00-00 backup dist:20

PQ Node (Node Protection): 0000.0000.0005.00-00 backup dist:20

Node: 0000.0000.0005.00-00

Interface eth3

P node: 0000.0000.0001 primary dist:10

```

P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20

PQ Node: 0000.0000.0004.00-00 backup dist:20
PQ Node (Node Protection): 0000.0000.0004.00-00 backup dist:20

Node: 0000.0000.0006.00-00
Interface eth3
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20

PQ Node: 0000.0000.0004.00-00 backup dist:20
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0007.00-00
Interface eth2
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

PQ Node: 0000.0000.0005.00-00 backup dist:20
No PQ Node found on backup path (Node Protection)

Tag 1: Level-2 Link State Database:

Node: 0000.0000.0001.00-00
Interface eth1
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20

```

```
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0001
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0003.00-00
Interface eth2
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0004.00-00
Interface eth2
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0005.00-00
Interface eth3
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
```

```

NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0006.00-00
Interface eth3
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0007.00-00
Interface eth2
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:30
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)
P1#
P1#
P1#show ip isis ri
P1#show ip isis route tilfa

Tag      : 1  VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2,
        C - Connected Routes, ia - IS-IS inter area

1.1.1.1/32
Route type: L1, FTN-ix :1  ILM-ix :5
SR Incoming Label      : 16001
Primary Path Nexthop    : 10.1.2.1, eth1
SR outgoing Label      : 3

```

No Backup

1.1.1.4/32

```
Route type: L1, FTN-ix :2  ILM-ix :6
SR Incoming Label      : 16004
Primary Path Nexthop   : 10.2.3.2, eth2
SR outgoing Label      : 16004
PQ node                : 1.1.1.5
Backup outgoing Label: 16004
Bypass_trunk id        : 2201
Backup out interface   : eth3
Protection Type         : Node Protecting

Trunk : 2202 :1.1.1.4_nh_10016_ALG0  FTN-ix : 7 ref_cnt:3
Number Of outgoing label : 1
16004
Nexthop address : 10.2.3.2
```

1.1.1.5/32

```
Route type: L1, FTN-ix :3  ILM-ix :7
SR Incoming Label      : 16005
Primary Path Nexthop   : 10.2.6.2, eth3
SR outgoing Label      : 16005
PQ node                : 1.1.1.4
Backup outgoing Label: 16005
Bypass_trunk id        : 2202
Backup out interface   : eth2
Protection Type         : Node Protecting

Trunk : 2201 :1.1.1.5_nh_10023_ALG0  FTN-ix : 6 ref_cnt:2
Number Of outgoing label : 1
16005
Nexthop address : 10.2.6.2
```

1.1.1.6/32

```
Route type: L1, FTN-ix :4  ILM-ix :8
SR Incoming Label      : 16006
Primary Path Nexthop   : 10.2.6.2, eth3
SR outgoing Label      : 3
PQ node                : 1.1.1.4
Backup outgoing Label: 16006
Bypass_trunk id        : 2202
Backup out interface   : eth2
Protection Type         : Link Protecting
```

1.1.1.7/32

```
Route type: L1, FTN-ix :5  ILM-ix :9
SR Incoming Label      : 16007
Primary Path Nexthop   : 10.2.3.2, eth2
SR outgoing Label      : 16007
PQ node                : 1.1.1.5
Backup outgoing Label: 16007
Bypass_trunk id        : 2201
Backup out interface   : eth3
Protection Type         : Link Protecting
```

P1#

P1#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, UPStr - upstream
```

ILM-ECMP LDP: Disabled, SR: Disabled

Code	FEC/VRF	Nexthop	ILM-ID	In-Label	Out-Label	In-Intf	Out-UPStr	peers
i>	10.2.3.2/32		3	24320	3	N/A	eth2	10.2
.3.2		Yes	0	00:01:00				
i>	1.1.1.4/32		6	16004	16004	N/A	eth2	10.2
.3.2		Yes	0	00:00:53				
i>	1.1.1.2/32		1	16002	Nolabel	N/A	N/A	127.0
.0.1		Yes	0	00:01:01				
i>	1.1.1.1/32		5	16001	3	N/A	eth1	10.1.
2.1		Yes	0	00:00:53				
i>	1.1.1.6/32		8	16006	16006	N/A	eth1	10.1.
2.1		Yes	0	00:00:53				
i>	1.1.1.5/32		7	16005	16005	N/A	eth2	10.2
.3.2		Yes	0	00:00:53				
i>	1.1.1.7/32		9	16007	16007	N/A	eth2	10.2
.3.2		Yes	0	00:00:53				
i>	10.2.6.2/32		2	24321	3	N/A	eth3	10.2
.6.2		Yes	0	00:01:00				
i>	10.1.2.1/32		4	24322	3	N/A	eth1	10.1.
2.1		Yes	0	00:01:00				

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, SR: Disabled

Code	FEC	Nexthop	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
i>	1.1.1.1/32		1	59	-	-	-	-
	-	0		00:01:00				
	10.1.2.1	-	-	48	0	Yes	3	eth1
								No
i>	1.1.1.4/32		2	85	-	-	-	-
	-	0		00:01:00				
	10.2.3.2	-	-	14	0	Yes	16004	eth2
								No
i>	1.1.1.5/32		3	79	-	-	-	-
	-	0		00:01:00				
	10.2.3.2	-	-	17	0	Yes	16005	eth2
								No
i>	1.1.1.6/32		4	82	-	-	-	-
	-	0		00:01:00				
	10.1.2.1	-	-	81	0	Yes	16006	eth1
								No
i>	1.1.1.7/32		5	87	-	-	-	-
	-	0		00:01:00				
	10.2.3.2	-	-	23	0	Yes	16007	eth2
								No

P1#

P1#show mpls ftn-table

Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State: Installed

CreateTime: 00:05:14, UpTime: 00:05:14, LastUpdate: N/A

Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none, Algorithm-Number: 0

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: 48 refcount: 1

Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up

State: Active

Out-segment with ix: 48, owner: N/A, Stale: NO, refcount: 3, out intf: xell, out label: 3

Nexthop addr: 10.1.2.1 cross connect ix: 4, op code: Push

```
Primary FTN entry with FEC: 1.1.1.4/32, id: 2, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:05:14, UpTime: 00:05:14, LastUpdate: 00:04:05
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm-Number: 0
  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: 14 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: ge6, out
  label: 16004
  Nexthop addr: 10.2.3.2          cross connect ix: 5, op code: Push

  Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 94 bypass ftn-ix: 6
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 94, owner: ISIS-SR, Stale: NO, refcount: 2, out intf: xe9, out
  label: 16004
  Nexthop addr: 10.2.6.2          cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 1.1.1.4/32, id: 7, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:04:10, UpTime: 00:04:10, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm-Number: 0
  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: 14 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: ge6, out
  label: 16004
  Nexthop addr: 10.2.3.2          cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 1.1.1.5/32, id: 3, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:05:14, UpTime: 00:05:14, LastUpdate: 00:04:05
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm-Number: 0
  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: 53 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 53, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe9, out
  label: 16005
  Nexthop addr: 10.2.6.2          cross connect ix: 9, op code: Push

  Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 17 bypass ftn-ix: 7
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, refcount: 4, out intf: ge6, out
  label: 16005
  Nexthop addr: 10.2.3.2          cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 1.1.1.5/32, id: 6, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:04:10, UpTime: 00:04:10, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm-Number: 0
  Tunnel id: 2201, 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: 53 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 53, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe9, out
```



```

label: 16005
  Nexthop addr: 10.2.6.2          cross connect ix: 9, op code: Push

  Primary FTN entry with FEC: 1.1.1.6/32, id: 4, row status: Active, Tunnel-Policy: N/A, State:
  Installed
  CreateTime: 00:05:14, UpTime: 00:05:14, LastUpdate: 00:04:05
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm-Number: 0
  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: 40 refcount: 1
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 40, owner: N/A, Stale: NO, refcount: 5, out intf: xe9, out label: 3
  Nexthop addr: 10.2.6.2          cross connect ix: 2, op code: Push

  Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 20 bypass ftn-ix: 7
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, refcount: 5, out intf: ge6, out
label: 16006
  Nexthop addr: 10.2.3.2          cross connect ix: 7, op code: Push

  Primary FTN entry with FEC: 1.1.1.7/32, id: 5, row status: Active, Tunnel-Policy: N/A, State:
  Installed
  CreateTime: 00:05:14, UpTime: 00:05:14, LastUpdate: 00:04:05
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm-Number: 0
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 23 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 23, owner: ISIS-SR, Stale: NO, refcount: 4, out intf: ge6, out
label: 16007
  Nexthop addr: 10.2.3.2          cross connect ix: 8, op code: Push

  Backup Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 101 bypass ftn-ix: 6
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 101, owner: ISIS-SR, Stale: NO, refcount: 2, out intf: xe9, out
label: 16007
  Nexthop addr: 10.2.6.2          cross connect ix: 7, op code: Push

```

TI-LFA FRR Path using a Direct Neighbor with OSPF-SR Configuration

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface eth3	Enter interface mode.
P1(config-if)#ip ospf cost 1000	Configure the OSPF cost for the interface
P1(config-if)#exit	Exit interface mode.
P1(config)#exit	Exit configure mode

P5

The following are the step-by-step configurations on the P5 router.

P5#configure terminal	Enter configure mode.
P5(config)#interface eth3	Enter interface mode.
P5(config-if)#ip ospf cost 1000	Configure the OSPF cost for the interface
P5(config-if)#exit	Exit interface mode.
P5(config)#exit	Exit configure mode

Validation**P1****Verify P1 Router**

```

P1#show ip ospf tilfa-backup-path

OSPF process 100:
Route [1.1.1.1]
  Primary Path Nexthop   : 10.1.2.1, eth1
  No PQ node
Route [1.1.1.3]
  Primary Path Nexthop   : 10.2.3.2, eth2
  PQ-node: 1.1.1.6
  Protection Type        : Node Protecting
Route [1.1.1.4]
  Primary Path Nexthop   : 10.2.3.2, eth2
  PQ-node: 1.1.1.6
  Protection Type        : Node Protecting
Route [1.1.1.5]
  Primary Path Nexthop   : 10.2.3.2, eth2
  PQ-node: 1.1.1.6
  Protection Type        : Node Protecting
Route [1.1.1.6]
  Primary Path Nexthop   : 10.2.3.2, eth2
  PQ-node: 1.1.1.6
  Protection Type        : Node Protecting
Route [1.1.1.7]
  Primary Path Nexthop   : 10.2.3.2, eth2
  PQ-node: 1.1.1.6
  Protection Type        : Node Protecting
Neighbor [1.1.1.1]
Neighbor [1.1.1.3]
  PQ-node: 1.1.1.6
Neighbor [1.1.1.6]
  PQ-node: 1.1.1.3

Displaying vertex-info in tilfa_network table
Vertex [1.1.1.1]
Interface: eth1
  P node: 1.1.1.4 dist: 2
  P node: 1.1.1.5 dist: 3
  P node: 1.1.1.6 dist: 4
  P node: 1.1.1.7 dist: 2
  P node: 1.1.1.3 dist: 1
  P node (Node Protection): 1.1.1.4 dist: 2
  P node (Node Protection): 1.1.1.5 dist: 3
  P node (Node Protection): 1.1.1.6 dist: 4

```

```
P node (Node Protection): 1.1.1.7 dist: 2
P node (Node Protection): 1.1.1.3 dist: 1
Q node: 1.1.1.1
No PQ node

Vertex [1.1.1.2]

Vertex [1.1.1.3]
Interface: eth2
  P node: 1.1.1.1 dist: 1
  P node: 1.1.1.3 dist: 1
  P node: 1.1.1.4 dist: 2
  P node: 1.1.1.5 dist: 3
  P node: 1.1.1.7 dist: 2
  P node: 1.1.1.6 dist: 4
  P node (Node Protection): 1.1.1.1 dist: 1
  P node (Node Protection): 1.1.1.4 dist: 2
  P node (Node Protection): 1.1.1.5 dist: 3
  P node (Node Protection): 1.1.1.6 dist: 4
  Q node: 1.1.1.3
  Q node: 1.1.1.4
  Q node: 1.1.1.5
  Q node: 1.1.1.6
  Q node: 1.1.1.7
  PQ-node: 1.1.1.6
  Backup out-interface: eth3
  PQ-node (Node Protection): 1.1.1.6
  Backup out-interface (Node Protection): eth3

Vertex [1.1.1.4]
Interface: eth2
  P node: 1.1.1.1 dist: 1
  P node: 1.1.1.3 dist: 1
  P node: 1.1.1.4 dist: 2
  P node: 1.1.1.5 dist: 3
  P node: 1.1.1.7 dist: 2
  P node: 1.1.1.6 dist: 4
  P node (Node Protection): 1.1.1.1 dist: 1
  P node (Node Protection): 1.1.1.4 dist: 2
  P node (Node Protection): 1.1.1.5 dist: 3
  P node (Node Protection): 1.1.1.6 dist: 4
  Q node: 1.1.1.3
  Q node: 1.1.1.4
  Q node: 1.1.1.5
  Q node: 1.1.1.6
  Q node: 1.1.1.7
  PQ-node: 1.1.1.6
  Backup out-interface: eth3
  PQ-node (Node Protection): 1.1.1.6
  Backup out-interface (Node Protection): eth3

Vertex [1.1.1.5]
Interface: eth2
  P node: 1.1.1.1 dist: 1
  P node: 1.1.1.3 dist: 1
  P node: 1.1.1.4 dist: 2
  P node: 1.1.1.5 dist: 3
  P node: 1.1.1.7 dist: 2
  P node: 1.1.1.6 dist: 4
  P node (Node Protection): 1.1.1.1 dist: 1
  P node (Node Protection): 1.1.1.4 dist: 2
  P node (Node Protection): 1.1.1.5 dist: 3
  P node (Node Protection): 1.1.1.6 dist: 4
  Q node: 1.1.1.3
  Q node: 1.1.1.4
  Q node: 1.1.1.5
  Q node: 1.1.1.6
  Q node: 1.1.1.7
```

```

PQ-node: 1.1.1.6
Backup out-interface: eth3
PQ-node (Node Protection): 1.1.1.6
Backup out-interface (Node Protection): eth3

Vertex [1.1.1.6]
Interface: eth2
P node: 1.1.1.1 dist: 1
P node: 1.1.1.3 dist: 1
P node: 1.1.1.4 dist: 2
P node: 1.1.1.5 dist: 3
P node: 1.1.1.7 dist: 2
P node: 1.1.1.6 dist: 4
P node (Node Protection): 1.1.1.1 dist: 1
P node (Node Protection): 1.1.1.4 dist: 2
P node (Node Protection): 1.1.1.5 dist: 3
P node (Node Protection): 1.1.1.6 dist: 4
Q node: 1.1.1.3
Q node: 1.1.1.4
Q node: 1.1.1.5
Q node: 1.1.1.6
Q node: 1.1.1.7
PQ-node: 1.1.1.6
Backup out-interface: eth3
PQ-node (Node Protection): 1.1.1.6
Backup out-interface (Node Protection): eth3

Vertex [1.1.1.7]
Interface: eth2
P node: 1.1.1.1 dist: 1
P node: 1.1.1.3 dist: 1
P node: 1.1.1.4 dist: 2
P node: 1.1.1.5 dist: 3
P node: 1.1.1.7 dist: 2
P node: 1.1.1.6 dist: 4
P node (Node Protection): 1.1.1.1 dist: 1
P node (Node Protection): 1.1.1.4 dist: 2
P node (Node Protection): 1.1.1.5 dist: 3
P node (Node Protection): 1.1.1.6 dist: 4
Q node: 1.1.1.3
Q node: 1.1.1.4
Q node: 1.1.1.5
Q node: 1.1.1.6
Q node: 1.1.1.7
PQ-node: 1.1.1.6
Backup out-interface: eth3
PQ-node (Node Protection): 1.1.1.6
Backup out-interface (Node Protection): eth3

P1#
P1#show ip ospf tilfa-repair-list

1.1.1.1/32
Primary Path Metric      :2
Route ftnix:8 ilmix:9
SR Incoming Label       : 16001
Primary Path Nexthop     : 10.1.2.1, eth1
SR outgoing Label       : 3
No PQ node

1.1.1.2/32
Primary Path Metric      :1
1.1.1.3/32
Primary Path Metric      :2
Route ftnix:1 ilmix:1
SR Incoming Label       : 16003
Primary Path Nexthop     : 10.2.3.2, eth2
SR outgoing Label       : 3

```

```
PQ-node: 1.1.1.6
Backup outgoing Label   : 16003
Bypass_trunk id :101
Backup out interface: eth3
Protection Type         : Node Protecting

Bypass-Trunk: 102 Name: 1.1.1.3_nexthop__10016 ftn_ix:7
ftn_info->trunk_ftn_ix  : 7, ref_cnt : 1
Number Of outgoing label: 1
  Outgoing labels:
    label 1: 3
Nexthop address: 10.2.3.2

1.1.1.4/32
Primary Path Metric    :3
Route ftnix:2 ilmix:2
SR Incoming Label     : 16004
Primary Path Nexthop   : 10.2.3.2, eth2
  SR outgoing Label    : 16004
  PQ-node: 1.1.1.6
  Backup outgoing Label : 16004
  Bypass_trunk id :101
  Backup out interface: eth3
  Protection Type      : Node Protecting

1.1.1.5/32
Primary Path Metric    :4
Route ftnix:3 ilmix:3
SR Incoming Label     : 16005
Primary Path Nexthop   : 10.2.3.2, eth2
  SR outgoing Label    : 16005
  PQ-node: 1.1.1.6
  Backup outgoing Label : 16005
  Bypass_trunk id :101
  Backup out interface: eth3
  Protection Type      : Node Protecting

1.1.1.6/32
Primary Path Metric    :5
Route ftnix:4 ilmix:4
SR Incoming Label     : 16006
Primary Path Nexthop   : 10.2.3.2, eth2
  SR outgoing Label    : 16006
  PQ-node: 1.1.1.6
  Backup outgoing Label : 3
  Bypass_trunk id :101
  Backup out interface: eth3
  Protection Type      : Node Protecting

Bypass-Trunk: 101 Name: 1.1.1.6_nexthop__10023 ftn_ix:6
ftn_info->trunk_ftn_ix  : 6, ref_cnt : 6
Number Of outgoing label: 1
  Outgoing labels:
    label 1: 3
Nexthop address: 10.2.6.2

1.1.1.7/32
Primary Path Metric    :3
Route ftnix:5 ilmix:5
SR Incoming Label     : 16007
Primary Path Nexthop   : 10.2.3.2, eth2
  SR outgoing Label    : 16007
  PQ-node: 1.1.1.6
  Backup outgoing Label : 16007
  Bypass_trunk id :101
  Backup out interface: eth3
  Protection Type      : Node Protecting
```

```

10.1.2.0/24
  Primary Path Metric :1
10.2.3.0/24
  Primary Path Metric :1
10.2.6.0/24
  Primary Path Metric :1000
10.3.4.0/24
  Primary Path Metric :2
10.3.7.0/24
  Primary Path Metric :2
10.4.5.0/24
  Primary Path Metric :3
10.5.6.0/24
  Primary Path Metric :4

```

```
P1#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, UPStr - upstream

```

```
ILM-ECMP LDP: Disabled, SR: Disabled
```

Code	FEC/VRF	Nexthop	ILM-ID	In-Label pri	Out-Label Algo-Num	In-Intf UpTime	Out- UPStr	peers
O>	1.1.1.6/32		4	16006	16006	N/A	eth2	10.2
.3.2		Yes	0	00:22:48	16006	3	N/A	eth3
.6.2		No	-	-				10.2
O>	1.1.1.4/32		2	16004	16004	N/A	eth2	10.2
.3.2		Yes	0	00:22:48	16004	16004	N/A	eth3
.6.2		No	-	-				10.2
O>	1.1.1.3/32		1	16003	3	N/A	eth2	10.2
.3.2		Yes	0	00:22:48	16003	16003	N/A	eth3
.6.2		No	-	-				10.2
O>	1.1.1.1/32		9	16001	3	N/A	eth1	10.1.
2.1		Yes	0	00:22:39				
O>	1.1.1.5/32		3	16005	16005	N/A	eth2	10.2
.3.2		Yes	0	00:22:48	16005	16005	N/A	eth3
.6.2		No	-	-				10.2
O>	10.2.3.2/32		6	24320	3	N/A	eth2	10.2
.3.2		Yes	0	00:22:48	24320	16003	N/A	eth3
.6.2		No	-	-				10.2
O>	1.1.1.7/32		5	16007	16007	N/A	eth2	10.2
.3.2		Yes	0	00:22:48	16007	16007	N/A	eth3
.6.2		No	-	-				10.2
O>	10.2.6.2/32		7	24321	3	N/A	eth3	10.2
.6.2		Yes	0	00:22:48	24321	16006	N/A	eth2
.3.2		No	-	-				10.2
O>	10.1.2.1/32		8	24322	3	N/A	eth1	10.1.
2.1		Yes	0	00:22:46				

```
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, SR: Disabled
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
------	-----	--------	----------	-----------	-----	-----------	------

```

Intf      ELC      Nexthop      Algo-Num  UpTime
O> 1.1.1.1/32      8      91      -      -      -      -
    -              0      00:22:56      13      0      Yes  3      eth1      No
    10.1.2.1      -      -
O> 1.1.1.3/32      1      9      -      -      -      -
    -              0      00:23:05      4      0      Yes  3      eth2      No
    10.2.3.2      -      -
    No      16003      eth3      No      10.2.6.2      -      -
O
(b)> 1.1.1.3/32      7      4      102      Yes  3      eth2      No
    10.2.3.2      0      00:02:41
O> 1.1.1.4/32      2      12      -      -      -      -
    -              0      00:23:05      7      0      Yes  16004      eth2      No
    10.2.3.2      -      -
    No      16004      eth3      No      10.2.6.2      -      -
O> 1.1.1.5/32      3      15      -      -      -      -
    -              0      00:23:05      89      0      Yes  16005      eth2      No
    10.2.3.2      -      -
    No      16005      eth3      No      10.2.6.2      -      -
O> 1.1.1.6/32      4      32      -      -      -      -
    -              0      00:23:05      94      0      Yes  16006      eth2      No
    10.2.3.2      -      -
    No      3      eth3      No      10.2.6.2      -      -
O
(b)> 1.1.1.6/32      6      1      101      Yes  3      eth3      No
    10.2.6.2      0      00:03:10
O> 1.1.1.7/32      5      34      -      -      -      -
    -              0      00:23:05      10      0      Yes  16007      eth2      No
    10.2.3.2      -      -
    No      16007      eth3      No      10.2.6.2      -      -

P1#show mpls ftn-table 1.1.1.6/32
Primary FTN entry with FEC: 1.1.1.6/32, id: 4, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:23:32, UpTime: 00:23:32, LastUpdate: 00:03:32
  Owner: OSPF-SR, distance: 110, Action-type: N/A, Exp-bits: 0x0, Incoming DSCP: none,
  Algorithm-Number: 0
  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: 94 refcount: 1
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 94, owner: OSPF-SR, Stale: NO, refcount: 3, out intf: eth2, out
  label: 16006
  Nexthop addr: 10.2.3.2      cross connect ix: 2, op code: Push

  Backup Cross connect ix: 9, in intf: - in label: 0 out-segment ix: 1 bypass ftn-ix: 6
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 1, owner: N/A, Stale: NO, refcount: 9, out intf: eth3, out label: 3
  Nexthop addr: 10.2.6.2      cross connect ix: 1, op code: Push

Primary FTN entry with FEC: 1.1.1.6/32, id: 6, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:03:37, UpTime: 00:03:37, LastUpdate: N/A
  Owner: OSPF-SR, distance: 110, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
  none, Algorithm-Number: 0
  Tunnel id: 101, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A, ,

```

```

Color: 0
  Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1 refcount: 1
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 1, owner: N/A, Stale: NO, refcount: 9, out intf: eth3, out label: 3
  Nexthop addr: 10.2.6.2      cross connect ix: 1, op code: Push

P1#show mpls ftn-table 1.1.1.7/32
  Primary FTN entry with FEC: 1.1.1.7/32, id: 5, row status: Active, Tunnel-Policy: N/A, State:
  Installed
  CreateTime: 00:23:41, UpTime: 00:23:41, LastUpdate: 00:03:41
  Owner: OSPF-SR, distance: 110, Action-type: N/A, Exp-bits: 0x0, Incoming DSCP: none,
  Algorithm-Number: 0
  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: 10 refcount: 1
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 10, owner: OSPF-SR, Stale: NO, refcount: 4, out intf: eth2, out
  label: 16007
  Nexthop addr: 10.2.3.2      cross connect ix: 4, op code: Push

  Backup Cross connect ix: 13, in intf: - in label: 0 out-segment ix: 28 bypass ftn-ix: 6
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 28, owner: OSPF-SR, Stale: NO, refcount: 2, out intf: eth3, out
  label: 16007
  Nexthop addr: 10.2.6.2      cross connect ix: 10, op code: Push

```

TI-LFA FRR Path using a Direct Neighbor with ISIS-SR Configuration

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface eth3	Enter interface mode.
P1(config-if)#isis wide-metric 1000	Configure the ISIS wide-metric for interface
P1(config-if)#exit	Exit interface mode.
P1(config)#exit	Exit configure mode
P1(config)#commit	Commit the candidate configuration to the running configuration.

P5

The following are the step-by-step configurations on the P5 router.

P5#configure terminal	Enter configure mode.
P5(config)#interface eth3	Enter interface mode.

P5(config-if)#isis wide-metric 1000	Configure the ISIS wide-metric for interface
P5(config-if)#exit	Exit interface mode.
P5(config)#exit	Exit configure mode
P5(config)#commit	Commit the candidate configuration to the running configuration.

Validation

P1

Verify P1 Router

```
P1#show isis tilfa pq

Tag 1: Level-1 Link State Database:

Node: 0000.0000.0001.00-00
Interface xell
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0006 primary dist:40
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0001
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0006 primary dist:40
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0003.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0004.00-00
```

```

Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
PQ Node (Node Protection): 0000.0000.0006.00-00 backup dist:1000

Node: 0000.0000.0005.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
PQ Node (Node Protection): 0000.0000.0006.00-00 backup dist:1000

Node: 0000.0000.0006.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

```

```
PQ Node: 0000.0000.0006.00-00 backup dist:1000
PQ Node (Node Protection): 0000.0000.0006.00-00 backup dist:1000

Node: 0000.0000.0007.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
No PQ Node found on backup path (Node Protection)

Tag 1: Level-2 Link State Database:

Node: 0000.0000.0001.00-00
Interface xell
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0006 primary dist:40
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0001
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:30
P node: 0000.0000.0006 primary dist:40
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0003.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
```

```
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0004.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
PQ Node (Node Protection): 0000.0000.0006.00-00 backup dist:1000

Node: 0000.0000.0005.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
PQ Node (Node Protection): 0000.0000.0006.00-00 backup dist:1000

Node: 0000.0000.0006.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:1030
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000
P node: 0000.0000.0007 primary dist:1040
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0005
Q node: 0000.0000.0006
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes
```

```
Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0004 primary dist:1020
P node: 0000.0000.0005 primary dist:1010
P node: 0000.0000.0006 primary dist:1000

PQ Node: 0000.0000.0006.00-00 backup dist:1000
PQ Node (Node Protection): 0000.0000.0006.00-00 backup dist:1000
Pl#
Pl#show ip isis route tilfa

Tag      : 1   VRF : default
Codes   : L1 - IS-IS level-1, L2 - IS-IS level-2,
          C - Connected Routes, ia - IS-IS inter area

1.1.1.1/32
Route type: L1, FTN-ix :1   ILM-ix :5
SR Incoming Label      : 16001
Primary Path Nexthop   : 10.1.2.1, xe11
SR outgoing Label      : 3
No Backup

1.1.1.4/32
Route type: L1, FTN-ix :2   ILM-ix :6
SR Incoming Label      : 16004
Primary Path Nexthop   : 10.2.3.2, ge6
SR outgoing Label      : 16004
PQ node                : 1.1.1.6
Backup outgoing Label: 16004
Bypass_trunk id        : 2203
Backup out interface   : xe9
Protection Type        : Node Protecting

1.1.1.5/32
Route type: L1, FTN-ix :3   ILM-ix :7
SR Incoming Label      : 16005
Primary Path Nexthop   : 10.2.3.2, ge6
SR outgoing Label      : 16005
PQ node                : 1.1.1.6
Backup outgoing Label: 16005
Bypass_trunk id        : 2203
Backup out interface   : xe9
Protection Type        : Node Protecting

1.1.1.6/32
Route type: L1, FTN-ix :4   ILM-ix :8
SR Incoming Label      : 16006
Primary Path Nexthop   : 10.2.3.2, ge6
SR outgoing Label      : 16006
PQ node                : 1.1.1.6
Backup outgoing Label: 3
Bypass_trunk id        : 2203
Backup out interface   : xe9
Protection Type        : Node Protecting

Trunk : 2203 :1.1.1.6_nh_10023_ALG0   FTN-ix : 8 ref_cnt:4
Number Of outgoing label : 1
3
Nexthop address : 10.2.6.2

1.1.1.7/32
Route type: L1, FTN-ix :5   ILM-ix :9
SR Incoming Label      : 16007
Primary Path Nexthop   : 10.2.3.2, ge6
```

```

SR outgoing Label      : 16007
PQ node                : 1.1.1.6
Backup outgoing Label  : 16007
Bypass_trunk id        : 2203
Backup out interface   : xe9
Protection Type        : Link Protecting

```

P1#

P1#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, UPStr - upstream

```

ILM-ECMP LDP: Disabled, SR: Disabled

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf	UPStr	peers
i>	10.2.3.2/32	3	24320	3	N/A	ge6		10.2.
3.2	Yes	0	00:13:15					
i>	1.1.1.4/32	6	16004	16004	N/A	ge6		10.2.
3.2	Yes	0	00:13:08					
			16004	16004	N/A	xe9		10.2.
6.2	No	-	-					
i>	1.1.1.2/32	1	16002	Nolabel	N/A	N/A		127.0
.0.1	Yes	0	00:13:16					
i>	1.1.1.1/32	5	16001	3	N/A	xe11		10.1.
2.1	Yes	0	00:13:08					
i>	1.1.1.6/32	8	16006	16006	N/A	ge6		10.2.
3.2	Yes	0	00:13:08					
			16006	3	N/A	xe9		10.2.
6.2	No	-	-					
i>	1.1.1.5/32	7	16005	16005	N/A	ge6		10.2.
3.2	Yes	0	00:13:08					
			16005	16005	N/A	xe9		10.2.
6.2	No	-	-					
i>	1.1.1.7/32	9	16007	16007	N/A	ge6		10.2.
3.2	Yes	0	00:13:08					
			16007	16007	N/A	xe9		10.2.
6.2	No	-	-					
i>	10.2.6.2/32	2	24321	3	N/A	xe9		10.2.
6.2	Yes	0	00:13:15					
i>	10.1.2.1/32	4	24322	3	N/A	xe11		10.1.
2.1	Yes	0	00:13:15					

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, SR: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-Intf
i>	1.1.1.1/32	1	59	-	-	-	-
	-	0	00:13:12				
			48	0	Yes	3	xe11
10.1.2.1	-	-					No
i>	1.1.1.4/32	2	109	-	-	-	-
	-	0	00:13:12				
			14	0	Yes	16004	ge6
10.2.3.2	-	-					No
			94	-			
	No	16004	xe9	No	10.2.6.2	-	-
i>	1.1.1.5/32	3	111	-	-	-	-
	-	0	00:13:12				

```

10.2.3.2      -      -      17      0      Yes      16005      ge6      No
                No      16005      xe9      No      10.2.6.2      -      -
i> 1.1.1.6/32      4      113      -      -      -      -
    -      0      00:13:12      20      0      Yes      16006      ge6      No
10.2.3.2      -      -      40      -
                No      3      xe9      No      10.2.6.2      -      -
i
(b)> 1.1.1.6/32      8      40      2203      Yes      3      xe9      No
    10.2.6.2      0      00:02:08
i> 1.1.1.7/32      5      115      -      -      -      -
    -      0      00:13:12      23      0      Yes      16007      ge6      No
10.2.3.2      -      -      101      -
                No      16007      xe9      No      10.2.6.2      -      -
P1#
P1#
P1#show mpls ftn-table
  Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 00:13:17, UpTime: 00:13:17, LastUpdate: N/A
    Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm-Number: 0
    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: 48 refcount: 1
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 48, owner: N/A, Stale: NO, refcount: 3, out intf: xe11, out label: 3
    Nexthop addr: 10.1.2.1      cross connect ix: 4, op code: Push

  Primary FTN entry with FEC: 1.1.1.4/32, id: 2, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 00:13:17, UpTime: 00:13:17, LastUpdate: 00:02:08
    Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm-Number: 0
    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: 14 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: ge6, out
    label: 16004
    Nexthop addr: 10.2.3.2      cross connect ix: 5, op code: Push

    Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 94 bypass ftn-ix: 8
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 94, owner: ISIS-SR, Stale: NO, refcount: 2, out intf: xe9, out
    label: 16004
    Nexthop addr: 10.2.6.2      cross connect ix: 1, op code: Push

  Primary FTN entry with FEC: 1.1.1.5/32, id: 3, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 00:13:17, UpTime: 00:13:17, LastUpdate: 00:02:08
    Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm-Number: 0
    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: 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: 4, out intf: ge6, out
    label: 16005
    Nexthop addr: 10.2.3.2      cross connect ix: 6, op code: Push

```

```
Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 53 bypass ftn-ix: 8
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
  Out-segment with ix: 53, owner: ISIS-SR, Stale: NO, refcount: 8, out intf: xe9, out
label: 16005
  Nexthop addr: 10.2.6.2          cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 1.1.1.6/32, id: 4, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:13:17, UpTime: 00:13:17, LastUpdate: 00:02:08
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  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: 20 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, refcount: 4, out intf: ge6, out
label: 16006
    Nexthop addr: 10.2.3.2          cross connect ix: 7, op code: Push

Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 40 bypass ftn-ix: 8
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
  Out-segment with ix: 40, owner: N/A, Stale: NO, refcount: 8, out intf: xe9, out label: 3
Nexthop addr: 10.2.6.2          cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 1.1.1.6/32, id: 8, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:02:13, UpTime: 00:02:13, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  Tunnel id: 2203, Protected LSP id: 0, LSP-type: Bypass, QoS Resource id: 0, Description: N/A,
, Color: 0
  Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 40 refcount: 1
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 40, owner: N/A, Stale: NO, refcount: 8, out intf: xe9, out label: 3
Nexthop addr: 10.2.6.2          cross connect ix: 2, op code: Push

Primary FTN entry with FEC: 1.1.1.7/32, id: 5, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:13:17, UpTime: 00:13:17, LastUpdate: 00:02:08
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 23 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 23, owner: ISIS-SR, Stale: NO, refcount: 4, out intf: ge6, out
label: 16007
    Nexthop addr: 10.2.3.2          cross connect ix: 8, op code: Push

Backup Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 101 bypass ftn-ix: 8
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
  Out-segment with ix: 101, owner: ISIS-SR, Stale: NO, refcount: 2, out intf: xe9, out
label: 16007
  Nexthop addr: 10.2.6.2          cross connect ix: 7, op code: Push
```


TI-LFA FRR Path using Adjacent P and Q nodes with OSPF-SR

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)#ip ospf cost 1000	Configure the OSPF cost for the interface
P4(config-if)#exit	Exit interface mode.
P4(config)#exit	Exit configure mode

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface eth3	Enter interface mode.
P3(config-if)#ip ospf cost 1000	Configure the OSPF cost for the interface
P3(config-if)#exit	Exit interface mode.
P3(config)#exit	Exit configure mode

Validation

P1

Verify P1 Router

```
P1#show ip ospf tilfa-backup-path

OSPF process 100:
Route [1.1.1.1]
  Primary Path Nexthop   : 10.1.2.1, eth1
  No PQ node
Route [1.1.1.3]
  Primary Path Nexthop   : 10.2.3.2, eth2
  No PQ node
Route [1.1.1.4]
  Primary Path Nexthop   : 10.2.3.2, eth2
  No PQ node
Route [1.1.1.6]
  Primary Path Nexthop   : 10.2.6.2, eth3
  P-node: 1.1.1.4        Q-node: 1.1.1.5
  Protection Type        : Node Protecting
Route [1.1.1.7]
  Primary Path Nexthop   : 10.2.3.2, eth2
  No PQ node
Neighbor [1.1.1.1]
```

```

Neighbor [1.1.1.3]
Neighbor [1.1.1.6]
    P-node: 1.1.1.4    Q-node: 1.1.1.5

Displaying vertex-info in tilfa_network table
Vertex [1.1.1.1]

Vertex [1.1.1.2]

Vertex [1.1.1.3]

Vertex [1.1.1.4]

Vertex [1.1.1.6]

Vertex [1.1.1.7]

Pl#show ip ospf tilfa-repair-list

1.1.1.1/32
    Primary Path Metric    :2
    Route ftnix:1 ilmix:2
    SR Incoming Label      : 16001
    Primary Path Nexthop    : 10.1.2.1, eth1
    SR outgoing Label      : 3
    No PQ node

1.1.1.2/32
    Primary Path Metric    :1

1.1.1.3/32
    Primary Path Metric    :2
    Route ftnix:3 ilmix:5
    SR Incoming Label      : 16003
    Primary Path Nexthop    : 10.2.3.2, eth2
    SR outgoing Label      : 3
    No PQ node

1.1.1.4/32
    Primary Path Metric    :3
    Route ftnix:4 ilmix:6
    SR Incoming Label      : 16004
    Primary Path Nexthop    : 10.2.3.2, eth2
    SR outgoing Label      : 16004
    No PQ node

Bypass-Trunk: 102 Name: 1.1.1.4_1.1.1.5_nexthop__10016 ftn_ix:8
ftn_info->trunk_ftn_ix    : 8, ref_cnt : 2
Number Of outgoing label: 2
    Outgoing labels:
        label 1: 16004
        label 2: 24320
Nextthop address: 10.2.3.2

1.1.1.5/32
    Primary Path Metric    :3
    Route ftnix:5 ilmix:7
    SR Incoming Label      : 16005
    Primary Path Nexthop    : 10.2.6.2, eth3
    SR outgoing Label      : 16005
    No PQ node

1.1.1.6/32
    Primary Path Metric    :2
    Route ftnix:6 ilmix:8
    SR Incoming Label      : 16006
    Primary Path Nexthop    : 10.2.6.2, eth3
    SR outgoing Label      : 3
    P-node: 1.1.1.4    Q-node: 1.1.1.5

```

```

Backup outgoing Label   : 16006
Bypass_trunk id :102
Backup out interface: eth2
Protection Type        : Node Protecting

1.1.1.7/32
Primary Path Metric    :3
Route ftnix:2 ilmix:4
SR Incoming Label      : 16007
Primary Path Nexthop    : 10.2.3.2, eth2
SR outgoing Label      : 16007
No PQ node

10.1.2.0/24
Primary Path Metric    :1
10.2.3.0/24
Primary Path Metric    :1
10.2.6.0/24
Primary Path Metric    :1
10.3.4.0/24
Primary Path Metric    :2
10.3.7.0/24
Primary Path Metric    :2
10.4.5.0/24
Primary Path Metric    :1002
10.5.6.0/24
Primary Path Metric    :2
P1#

P1#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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code  FEC/VRF/L2CKT  ILM-ID  In-Label  Out-Label  In-Intf  Out-
Intf/VRF  Nexthop      pri  Algo-Num  UpTime    UPStr peers
O>  1.1.1.7/32      4      16007     16007     N/A      eth2      10.2
.3.2      Yes  0      00:04:10  16007     N/A      eth3      10.2
.6.2      No  -      -         -         N/A      eth2      10.2
O>  1.1.1.3/32      5      16003     3         N/A      eth2      10.2
.3.2      Yes  0      00:04:21  16003     N/A      eth3      10.2
.6.2      No  -      -         -         N/A      eth1      10.1
O>  1.1.1.1/32      2      16001     3         N/A      eth1      10.1
2.1      Yes  0      00:04:26  16005     N/A      eth3      10.2
O>  1.1.1.5/32      7      16005     16005     N/A      eth3      10.2
.6.2      Yes  0      00:01:19  16005     N/A      eth2      10.2
.3.2      No  -      -         -         N/A      eth2      10.2
O>  1.1.1.4/32      6      16004     16004     N/A      eth2      10.2
.3.2      Yes  0      00:03:20  16004     N/A      eth3      10.2
.6.2      No  -      -         -         N/A      eth3      10.2
O>  1.1.1.6/32      8      16006     3         N/A      eth3      10.2
.6.2      Yes  0      00:03:20  16006     N/A      eth2      10.2
.3.2      No  -      -         -         N/A      eth1      10.1
O>  10.1.2.1/32     3      24321     3         N/A      eth1      10.1
2.1      Yes  0      00:04:25  24320     3         N/A      eth2      10.2
O>  10.2.3.2/32     1      24320     3         N/A      eth2      10.2
.3.2      Yes  0      00:04:27  24320     16003     N/A      eth3      10.2
.6.2      No  -      -         -         N/A      eth3      10.2
O>  10.2.6.2/32     9      24322     3         N/A      eth3      10.2

```

```

.6.2          Yes  0          00:03:20
                24322          16006          N/A          eth2          10.2

.3.2          No   -          -
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, SR: Disabled
Code  FEC      Nexthop  FTN-ID  Nhlfe-ID  Tunnel-ID  Pri  Out-Label  Out-
Intf  ELC              Algo-Num  UpTime
O>    1.1.1.1/32    1        154      -          -          -    -          -
      -            0        00:04:30  13         0          Yes   3          eth1      No
10.1.2.1 -          -          -
O>    1.1.1.3/32    3        193      -          -          -    -          -
      -            0        00:04:25  4         0          Yes   3          eth2      No
10.2.3.2 -          -          -
      No 16003      eth3      No 10.2.6.2    -          -
O>    1.1.1.4/32    4        195      -          -          -    -          -
      -            0        00:03:24  7         0          Yes  16004      eth2      No
10.2.3.2 -          -          -
      No 3          eth3      No 10.2.6.2    -          -
O
(b)>   1.1.1.4/32    8        7        102        Yes  16004      eth2      No
10.2.3.2 0        00:03:18
O>    1.1.1.5/32    5        197      -          -          -    -          -
      -            0        00:01:23  16        0          Yes  16005      eth3      No
10.2.6.2 -          -          -
      No 3          eth2      No 10.2.3.2    -          -
O
(b)>   1.1.1.5/32    7        16        101        Yes  16005      eth3      No
10.2.6.2 0        00:01:17
O>    1.1.1.6/32    6        178      -          -          -    -          -
      -            0        00:03:24  1         0          Yes   3          eth3      No
10.2.6.2 -          -          -
      No 16006      eth2      No 10.2.3.2    -          -
O>    1.1.1.7/32    2        200      -          -          -    -          -
      -            0        00:04:14  10        0          Yes  16007      eth2      No
10.2.3.2 -          -          -
      No 16007      eth3      No 10.2.6.2    -          -
P1#

P1#show mpls ftn-table 1.1.1.6/32
Primary FTN entry with FEC: 1.1.1.6/32, id: 6, row status: Active, Tunnel-Policy: N/A, State:
Installed
CreateTime: 00:03:55, UpTime: 00:03:55, LastUpdate: 00:03:44
Owner: OSPF-SR, distance: 110, Action-type: N/A, Exp-bits: 0x0, Incoming DSCP: none,
Algorithm-Number: 0
Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 1 refcount: 1
Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
Out-segment with ix: 1, owner: N/A, Stale: NO, refcount: 15, out intf: eth3, out label: 3
Nexthop addr: 10.2.6.2      cross connect ix: 1, op code: Push

```

```

Backup Cross connect ix: 10, in intf: - in label: 0 out-segment ix: 94 bypass ftn-ix: 8
Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
State: Active
  Out-segment with ix: 94, owner: OSPF-SR, Stale: NO, refcount: 7, out intf: eth2, out
label: 16006
  Nexthop addr: 10.2.3.2          cross connect ix: 2, op code: Push

P1#show mpls ftn-table 1.1.1.7/32
Primary FTN entry with FEC: 1.1.1.7/32, id: 2, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:04:54, UpTime: 00:04:54, LastUpdate: 00:01:52
  Owner: OSPF-SR, distance: 110, Action-type: N/A, Exp-bits: 0x0, Incoming DSCP: none,
Algorithm-Number: 0
  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: 10 refcount: 1
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 10, owner: OSPF-SR, Stale: NO, refcount: 8, out intf: eth2, out
label: 16007
  Nexthop addr: 10.2.3.2          cross connect ix: 4, op code: Push

  Backup Cross connect ix: 2, in intf: - in label: 0 out-segment ix: 199 bypass ftn-ix: 7
  Owner: OSPF-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 199, owner: OSPF-SR, Stale: NO, refcount: 2, out intf: eth3, out
label: 16007
  Nexthop addr: 10.2.6.2          cross connect ix: 2, op code: Push

```

TI-LFA FRR Path using Adjacent P and Q nodes with ISIS-SR

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)#isis wide-metric 1000	Configure the OSPF cost for the interface
P4(config-if)#exit	Exit interface mode.
P4(config)#exit	Exit configure mode

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)#isis wide-metric 1000	Configure the OSPF cost for the interface
P3(config-if)#exit	Exit interface mode.
P3(config)#exit	Exit configure mode

Validation

P1

Verify P1 Router

```
P1#show isis tilfa pq

Tag 1: Level-1 Link State Database:

Node: 0000.0000.0001.00-00
Interface xell
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0001
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0003.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

P-Node: 0000.0000.0005.00-00 backup dist:20
Q-Node: 0000.0000.0004.00-00 backup dist:10020
No PQ Node found on backup path (Node Protection)
```

```
Node: 0000.0000.0004.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

P-Node: 0000.0000.0005.00-00 backup dist:20
Q-Node: 0000.0000.0004.00-00 backup dist:10020
P-Node (Node Protection): 0000.0000.0005.00-00 backup dist:20
Q-Node (Node Protection): 0000.0000.0004.00-00 backup dist:10020

Node: 0000.0000.0005.00-00
Interface xe9
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0005
Q node: 0000.0000.0006
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20

P-Node: 0000.0000.0004.00-00 backup dist:20
Q-Node: 0000.0000.0005.00-00 backup dist:10020
P-Node (Node Protection): 0000.0000.0004.00-00 backup dist:20
Q-Node (Node Protection): 0000.0000.0005.00-00 backup dist:10020

Node: 0000.0000.0006.00-00
Interface xe9
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0005
Q node: 0000.0000.0006
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20

P-Node: 0000.0000.0004.00-00 backup dist:20
Q-Node: 0000.0000.0005.00-00 backup dist:10020
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0007.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
```

```
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

P-Node: 0000.0000.0005.00-00 backup dist:20
Q-Node: 0000.0000.0004.00-00 backup dist:10020
No PQ Node found on backup path (Node Protection)

Tag 1: Level-2 Link State Database:

Node: 0000.0000.0001.00-00
Interface xell
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0001
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
P node: 0000.0000.0007 primary dist:20

No PQ Node found on backup path
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0003.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

P-Node: 0000.0000.0005.00-00 backup dist:20
Q-Node: 0000.0000.0004.00-00 backup dist:10020
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0004.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
```



```
P-Node: 0000.0000.0005.00-00 backup dist:20
Q-Node: 0000.0000.0004.00-00 backup dist:10020
P-Node (Node Protection): 0000.0000.0005.00-00 backup dist:20
Q-Node (Node Protection): 0000.0000.0004.00-00 backup dist:10020

Node: 0000.0000.0005.00-00
Interface xe9
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0005
Q node: 0000.0000.0006
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20

P-Node: 0000.0000.0004.00-00 backup dist:20
Q-Node: 0000.0000.0005.00-00 backup dist:10020
P-Node (Node Protection): 0000.0000.0004.00-00 backup dist:20
Q-Node (Node Protection): 0000.0000.0005.00-00 backup dist:10020

Node: 0000.0000.0006.00-00
Interface xe9
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20
Q node: 0000.0000.0005
Q node: 0000.0000.0006
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0003 primary dist:10
P node: 0000.0000.0004 primary dist:20
P node: 0000.0000.0007 primary dist:20

P-Node: 0000.0000.0004.00-00 backup dist:20
Q-Node: 0000.0000.0005.00-00 backup dist:10020
No PQ Node found on backup path (Node Protection)

Node: 0000.0000.0007.00-00
Interface ge6
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10
Q node: 0000.0000.0003
Q node: 0000.0000.0004
Q node: 0000.0000.0007
NO SRLG Protecting P Nodes

Node Protecting P Nodes
P node: 0000.0000.0001 primary dist:10
P node: 0000.0000.0005 primary dist:20
P node: 0000.0000.0006 primary dist:10

P-Node: 0000.0000.0005.00-00 backup dist:20
Q-Node: 0000.0000.0004.00-00 backup dist:10020
No PQ Node found on backup path (Node Protection)
P1#
P1#
P1#show ip isis route tilfa
```

```
Tag : 1 VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2,
        C - Connected Routes, ia - IS-IS inter area

1.1.1.1/32
Route type: L1, FTN-ix :1 ILM-ix :5
SR Incoming Label : 16001
Primary Path Nexthop : 10.1.2.1, xe11
SR outgoing Label : 3
No Backup

1.1.1.4/32
Route type: L1, FTN-ix :2 ILM-ix :6
SR Incoming Label : 16004
Primary Path Nexthop : 10.2.3.2, ge6
SR outgoing Label : 16004
P node : 1.1.1.5
Q node : 1.1.1.4
Backup outgoing Label: 3
Bypass_trunk id : 2201
Backup out interface : xe9
Protection Type : Node Protecting

Trunk : 2202 :1.1.1.4_1.1.1.5_nh_10016_ALG0 FTN-ix : 7 ref_cnt:3
Number Of outgoing label : 2
16004
24321
Nexthop address : 10.2.3.2

1.1.1.5/32
Route type: L1, FTN-ix :3 ILM-ix :7
SR Incoming Label : 16005
Primary Path Nexthop : 10.2.6.2, xe9
SR outgoing Label : 16005
P node : 1.1.1.4
Q node : 1.1.1.5
Backup outgoing Label: 3
Bypass_trunk id : 2202
Backup out interface : ge6
Protection Type : Node Protecting

Trunk : 2201 :1.1.1.5_1.1.1.4_nh_10023_ALG0 FTN-ix : 6 ref_cnt:2
Number Of outgoing label : 2
16005
24320
Nexthop address : 10.2.6.2

1.1.1.6/32
Route type: L1, FTN-ix :4 ILM-ix :8
SR Incoming Label : 16006
Primary Path Nexthop : 10.2.6.2, xe9
SR outgoing Label : 3
P node : 1.1.1.4
Q node : 1.1.1.5
Backup outgoing Label: 16006
Bypass_trunk id : 2202
Backup out interface : ge6
Protection Type : Link Protecting

1.1.1.7/32
Route type: L1, FTN-ix :5 ILM-ix :9
SR Incoming Label : 16007
Primary Path Nexthop : 10.2.3.2, ge6
SR outgoing Label : 16007
```

```

P node           : 1.1.1.5
Q node           : 1.1.1.4
Backup outgoing Label: 16007
Bypass_trunk id   : 2201
Backup out interface : xe9
Protection Type    : Link Protecting

```

```
P1#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, UPStr - upstream

```

```
ILM-ECMP LDP: Disabled, SR: Disabled
```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-Intf	UPStr	peers
Intf/VRF	Nexthop		pri	Algo-Num	UpTime			
i> 10.2.3.2/32	Yes 0	3	24320	3	N/A	ge6		10.2.
3.2			00:00:38					
i> 1.1.1.5/32	Yes 0	7	16005	16005	N/A	xe9		10.2.
6.2			00:00:36					
			16005	3	N/A	ge6		10.2.
3.2	No -	-	-					
i> 1.1.1.2/32	Yes 0	1	16002	Nolabel	N/A	N/A		127.0
.0.1			00:00:39					
i> 1.1.1.1/32	Yes 0	5	16001	3	N/A	xe11		10.1.
2.1			00:00:36					
i> 1.1.1.4/32	Yes 0	6	16004	16004	N/A	ge6		10.2.
3.2			00:00:36					
			16004	3	N/A	xe9		10.2.
6.2	No -	-	-					
i> 1.1.1.6/32	Yes 0	8	16006	3	N/A	xe9		10.2.
6.2			00:00:36					
			16006	16006	N/A	ge6		10.2.
3.2	No -	-	-					
i> 1.1.1.7/32	Yes 0	9	16007	16007	N/A	ge6		10.2.
3.2			00:00:36					
			16007	16007	N/A	xe9		10.2.
6.2	No -	-	-					
i> 10.2.6.2/32	Yes 0	2	24321	3	N/A	xe9		10.2.
6.2			00:00:38					
			24321	16006	N/A	ge6		10.2.
3.2	No -	-	-					
i> 10.1.2.1/32	Yes 0	4	24322	3	N/A	xe11		10.1.
2.1			00:00:38					

```
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, SR: Disabled
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-Intf	peers
Intf	ELC	Nexthop	Algo-Num	UpTime				
i> 1.1.1.1/32	-	1	26	-	-	-	-	-
		0	00:00:39					
			24	0	Yes	3	xe11	No
10.1.2.1	-	-						
i> 1.1.1.4/32	-	2	36	-	-	-	-	-
		0	00:00:39					
			14	0	Yes	16004	ge6	No
10.2.3.2	-	-						
			40	-				
	No	3	xe9	No		10.2.6.2	-	-

```
i
```

```

(b)> 1.1.1.4/32      7      14      2202      Yes  16004      ge6      No
    10.2.3.2      0      00:00:38
i> 1.1.1.5/32      3      38      -      -      -      -      -
    -      0      00:00:39
        53      0      Yes  16005      xe9      No
    10.2.6.2      -      -      46      -
        No  3      ge6      No  10.2.3.2      -      -
i
(b)> 1.1.1.5/32      6      53      2201      Yes  16005      xe9      No
    10.2.6.2      0      00:00:38
i> 1.1.1.6/32      4      41      -      -      -      -      -
    -      0      00:00:39
        40      0      Yes  3      xe9      No
    10.2.6.2      -      -      20      -
        No  16006      ge6      No  10.2.3.2      -      -
i> 1.1.1.7/32      5      44      -      -      -      -      -
    -      0      00:00:39
        23      0      Yes  16007      ge6      No
    10.2.3.2      -      -      43      -
        No  16007      xe9      No  10.2.6.2      -      -
P1#
P1#show mmmmp
P1#show mpls ftn-table
  Primary FTN entry with FEC: 1.1.1.1/32, id: 1, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 00:00:46, UpTime: 00:00:46, LastUpdate: N/A
    Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm-Number: 0
    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: 24 refcount: 1
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 24, owner: N/A, Stale: NO, refcount: 3, out intf: xe11, out label: 3
    Nexthop addr: 10.1.2.1      cross connect ix: 4, op code: Push

  Primary FTN entry with FEC: 1.1.1.4/32, id: 2, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 00:00:46, UpTime: 00:00:46, LastUpdate: 00:00:40
    Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm-Number: 0
    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: 14 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, refcount: 10, out intf: ge6, out
    label: 16004
    Nexthop addr: 10.2.3.2      cross connect ix: 5, op code: Push

    Backup Cross connect ix: 1, in intf: - in label: 0 out-segment ix: 40 bypass ftn-ix: 6
    Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 40, owner: N/A, Stale: NO, refcount: 13, out intf: xe9, out label: 3
    Nexthop addr: 10.2.6.2      cross connect ix: 2, op code: Push

  Primary FTN entry with FEC: 1.1.1.4/32, id: 7, row status: Active, Tunnel-Policy: N/A, State:
  Installed
    CreateTime: 00:00:45, UpTime: 00:00:45, LastUpdate: N/A
    Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
    none, Algorithm-Number: 0
    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: 14 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up

```

```
State: Active
  Out-segment with ix: 14, owner: ISIS-SR, Stale: NO, refcount: 10, out intf: ge6, out
label: 16004\24321
  Nexthop addr: 10.2.3.2          cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 1.1.1.5/32, id: 3, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:00:46, UpTime: 00:00:46, LastUpdate: 00:00:40
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  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: 53 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 53, owner: ISIS-SR, Stale: NO, refcount: 12, out intf: xe9, out
label: 16005
  Nexthop addr: 10.2.6.2          cross connect ix: 9, op code: Push

  Backup Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 46 bypass ftn-ix: 7
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 46, owner: N/A, Stale: NO, refcount: 4, out intf: ge6, out label: 3
  Nexthop addr: 10.2.3.2          cross connect ix: 3, op code: Push

Primary FTN entry with FEC: 1.1.1.5/32, id: 6, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:00:45, UpTime: 00:00:45, LastUpdate: N/A
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  Tunnel id: 2201, 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: 53 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 53, owner: ISIS-SR, Stale: NO, refcount: 12, out intf: xe9, out
label: 16005\24320
  Nexthop addr: 10.2.6.2          cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 1.1.1.6/32, id: 4, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:00:46, UpTime: 00:00:46, LastUpdate: 00:00:40
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  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: 40 refcount: 1
  Owner: N/A, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 40, owner: N/A, Stale: NO, refcount: 13, out intf: xe9, out label: 3
  Nexthop addr: 10.2.6.2          cross connect ix: 2, op code: Push

  Backup Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 20 bypass ftn-ix: 7
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 20, owner: ISIS-SR, Stale: NO, refcount: 7, out intf: ge6, out
label: 16006
  Nexthop addr: 10.2.3.2          cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 1.1.1.7/32, id: 5, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:00:46, UpTime: 00:00:46, LastUpdate: 00:00:40
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
  Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 23 refcount: 1
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
```

```

State: Active
  Out-segment with ix: 23, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: ge6, out
label: 16007
    Nexthop addr: 10.2.3.2          cross connect ix: 8, op code: Push

  Backup Cross connect ix: 7, in intf: - in label: 0  out-segment ix: 43  bypass ftn-ix: 6
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 43, owner: ISIS-SR, Stale: NO, refcount: 2, out intf: xe9, out
label: 16007
    Nexthop addr: 10.2.6.2          cross connect ix: 7, op code: Push

```

TI-LFA FRR for SR-Policy

The active segment of a packet (ie., the top label of the packet as seen by the receiving router) that is being forwarded using an SR-policy can be protected upon failure of its primary outgoing interface by enabling FRR for the SR-policy.

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#segment-routing	Configuring segment-routing.
P1(config-sr)#traffic-engineering	Segment Routing traffic engineering.
P1(config-sr-te)#segment-list p5-p4-pe2	Configure a segment-lis.
P1(config-sr-sl)#index 10 segment-type-1 16006	Configure the segment-list entry with index 10 and label as prefix-sid of P5.
P1(config-sr-sl)#index 20 segment-type-1 16005	Configure the segment-list entry with index 10 and label as prefix-sid of P4.
P1(config-sr-sl)#index 30 segment-type-1 16007	Configure the segment-list entry with index 10 and label as prefix-sid of PE2.
P1(config-sr-sl)#exit-sr-sl	Exit segment-routing segment-list mode.
P1(config-sr-te)#policy to-pe2	Configure an SR-policy.
P1(config-sr-pol)#color 11 end-point 1.1.1.7	Configure SR-policy with key ie., color and end-point.
P1(config-sr-pol)#candidate-path 11	Configure a candidate-path for the SR-policy.
P1(config-sr-pol-cp)#preference 100	Configure the preference value for the candidate-path.
P1(config-sr-pol-cp)#explicit segment-list p5-p4-pe2	Configure the candidate-path as explicit-path with segment- list.
P1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode.
P1(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode.

P1(config-sr-te)#policy-fast-reroute-enable	Enable segment-routing policy fast-reroute.
P1(config-sr-te)#exit	Exit segment-routing mode.
P1(config)#exit	Exit configure terminal mode .
P1(config)#commit	Commit the candidate configuration to the running configuration
P1(config-router)# fast-reroute per-prefix ti-lfa area 0.0.0.0	Enable per-prefix TI-LFA FRR computation for OSPF area 0
P1(config-router)#exit	Exit router mode.
P1(config-router)#network 1.1.1.2/32 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.1.2.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.2.3.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#network 10.2.6.0/24 area 0.0.0.0	Configure OSPF network in area 0
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config)#commit	Commit the candidate configuration to the running configuration.
P1(config)#exit	Exit configure mode

Validation

P1

Verify P1 Router

```
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, SR: Disabled
Code   FEC          NextHop    FTN-ID   Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC           UpTime
i>     1.1.1.1/32    0          1        48        -          -     -          -
      -           0          00:11:27  47        0          Yes   16001      eth1      No
      10.1.2.1    -          -         -         -         -          -     -          -
i>     1.1.1.4/32    0          2        60        -          -     -          -
      -           0          00:11:27  7         0          Yes   16004      eth2      No
      10.2.3.2    -          -         1         -          -     -          -
      No         3          eth3      No        10.2.6.2   -     -          -
i
(b)>   1.1.1.4/32    7          7        7         2202       Yes   16004      eth2      No
      10.2.3.2    0          00:11:25
i>     1.1.1.5/32    3          62        -          -          -     -          -
      -           0          00:11:27  16        0          Yes   16005      eth3      No
      10.2.6.2    -          -         -         -          -     -          -
```

```

i
(b)> 1.1.1.5/32      6      16      2201      Yes      16005      eth3      No
      10.2.6.2      0      00:11:25
i> 1.1.1.6/32      4      64      -      -      -      -      -
      -      0      00:11:27
      10.2.6.2      -      -      29      0      Yes      16006      eth3      No
      No      16006      eth2      No      10.2.3.2      -      -
P> 1.1.1.7/32      8      76      1      Yes      16006      eth3      No
      10.2.6.2      N/A      00:00:31
i> 1.1.1.7/32      5      73      -      -      -      -      -
      -      0      00:00:37
      10.2.3.2      -      -      10      0      Yes      16007      eth2      No
      No      16007      eth3      No      10.2.6.2
P1#show mpls ftn-table 1.1.1.7/32
Primary FTN entry with FEC: 1.1.1.7/32, id: 8, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:01:03, UpTime: 00:01:03, LastUpdate: N/A
  Owner: SR_POLICY, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  Tunnel id: 1, Protected LSP id: 0, LSP-type: Primary, QoS Resource id: 0, Description: to-pe2,
, Color: 11
    Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 75 refcount: 1
    Owner: SR_POLICY, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 75, owner: SR_POLICY, Stale: NO, refcount: 1, out intf: eth3, out
label: 16006\16005\16007
    Nexthop addr: 10.2.6.2 Trunk: 1      cross connect ix: 11, op code: Push

Primary FTN entry with FEC: 1.1.1.7/32, id: 5, row status: Active, Tunnel-Policy: N/A, State:
Installed
  CreateTime: 00:01:09, UpTime: 00:01:09, LastUpdate: 00:01:03
  Owner: ISIS-SR, distance: 115, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP:
none, Algorithm-Number: 0
  Tunnel id: 0, Protected LSP id: 0, LSP-type: Primary, Description: N/A, , Color: 0
    Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 10 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    State: Active
    Out-segment with ix: 10, owner: OSPF-SR, Stale: NO, refcount: 25, out intf: eth2, out
label: 16007
    Nexthop addr: 10.2.3.2      cross connect ix: 8, op code: Push

Backup Cross connect ix: 7, in intf: - in label: 0 out-segment ix: 72 bypass ftn-ix: 6
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  State: Active
  Out-segment with ix: 72, owner: ISIS-SR, Stale: NO, refcount: 2, out intf: eth3, out
label: 16007
  Nexthop addr: 10.2.6.2      cross connect ix: 7, op code: Push

P1#show mpls ilm-table 1.1.1.7/32
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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code   FEC/VRF/L2CKT   ILM-ID   In-Label   Out-Label   In-Intf   Out-
Intf/VRF   Nexthop       pri Algo-Num UpTime     UPStr peers
i> 1.1.1.7/32      9        16007      16007      N/A        eth2      10.2
.3.2      Yes 0        00:01:46      16007      16007      N/A        eth3      10.2
.6.2      No -        -            -            -            -            -

```


P>	1.1.1.7/32	10	24960	16006	N/A	eth3	10.2
.6.2		Yes N/A	00:01:40				

TILFA for ISIS SR with Flexible Algorithms

Overview

Topology Independent Loop-Free Alternate (TI-LFA) for IS-IS Segment Routing (SR) with Flexible Algorithm (Flex-Algo) provides fast reroute protection (FRR), minimizes downtime, and provides re-convergence on failure detection.

Feature Characteristics

- IS-IS supports per-algorithm TI-LFA backup path calculation.
- TI-LFA backup path calculation for the default SPF algorithm is supported.
- TI-LFA path computation for flex-algos is based on constraint matching against the TE attributes of nodes and links.
- Backup path computation adheres to the same constraints as the primary path. These constraints are defined by the winner node of the flex-algo typically the node with the highest priority, or the highest router ID if multiple nodes have the same priority value.
- HSL is programmed with primary and backup LSP's for each specific flex-algo.

Benefits

This feature offers several key advantages:

- Sub-50ms Fast Reroute (FRR): Rapid recovery from link or node failures with precomputed backup paths.
- Algorithm-Aware Protection: Backup paths adhere to Flex-Algo constraints, enabling per-service or class-based protection.
- Prefix-Independent Backup: A single backup path protects multiple prefixes, reducing processing overhead.
- Constraint-Based Traffic Engineering: Ensures TE policies (For example: low latency, disjoint paths) are preserved during failures.
- Service Differentiation: Supports multiple algorithms tailored for specific application needs.
- Simplified Scalability: Avoids per-flow state and RSVP-TE complexity, enabling scalable, policy-driven routing.

Limitations

- Supports ISIS enhancements for Flexible Algorithms.
- Traffic Engineering and Segment Routing configurations must be enabled to advertise sub-TLVs.
- Dynamic SR-Policy creation based on Flex-Algo ID for path calculation is not supported in this release.
- Flexible Algorithm paths are not compatible with LDP-to-SR stitching. SR paths calculated using delay as a metric will not interwork with LDP paths calculated using IGP metrics.
- Router capability advertisements containing FAD TLVs require SR to be configured. LDP-only domains without SR cannot participate in Flex-Algo computations.
- IGP-based micro-loop avoidance is currently limited to Default Algorithm paths.

- BGP-LS extensions for Flex-Algo are not supported.
- Flexible Algorithm-specific IS-IS Adjacency Segment extensions are not supported.
- A maximum of eight Flexible Algorithms is supported.
- Fallback to the Default Algorithm is not supported.

Prerequisites

The TI-LFA for IS-IS Segment Routing with Flex-Algo feature can be enabled on OcNOS devices that meet the following requirements:

- Support for IS-IS Segment Routing with Flex-Algo, Equal-Cost Multi-Path (ECMP), and TI-LFA.
- Support for BGP-based services, including VPLS, L3VPN, and 6VPE.
- Support for EVPN services.

Configuration

The following configuration enables TILFA for ISIS-SR with Flex-Algo.

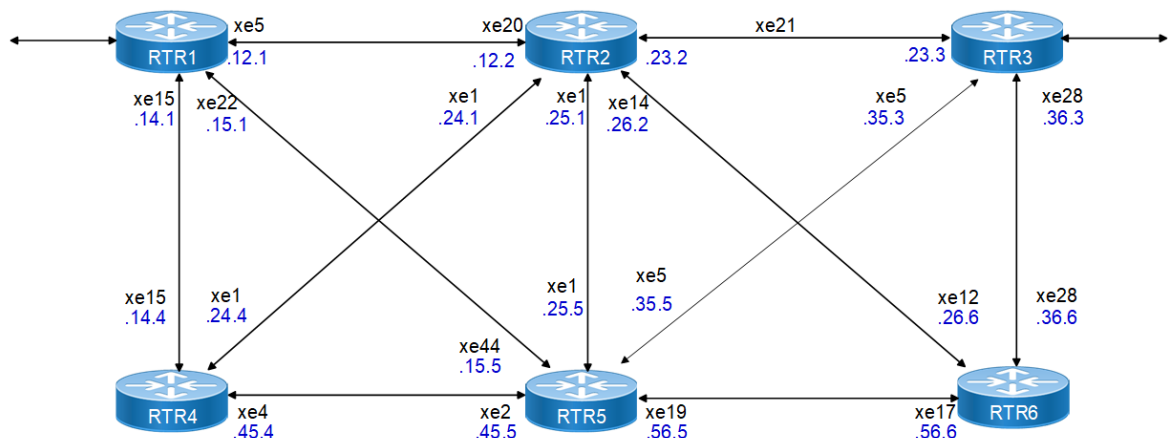
Topology

The topology consists of six routers configured to validate the TI-LFA feature for fast reroute protection in an SR-MPLS network.

- RTR1 and RTR3 serve as Provider Edge (PE) routers and are the primary devices under test.
- RTR2, RTR4, and RTR6 function primarily as core (P) routers, forwarding traffic through the network.
- RTR5 is a hybrid node acting both as a core router and as a Route Reflector (RR) for control-plane scalability.

The network includes diverse interconnections across the core, providing multiple Equal-Cost Multi-Path (ECMP) and non-ECMP paths. This setup enables the evaluation of TI-LFA behavior under various failure scenarios, including link and node failures, and ensures that backup paths are precomputed and meet the sub-50ms convergence requirement.

Figure 26. Logical Topologies Based on Flexible Algorithms



To configure Flex Algo functionality on nodes with ISIS as IGP, follow the steps mentioned below:

1. Configure loop-back interfaces.

- Access interface configuration mode for the loopback interface (interface loopback1).
- Assign an IPv4 address to the loopback interface using the IPv4 address command followed by the desired
- IPv4 address and subnet mask (ip address 25.0.0.1/32).
- Assign appropriate prefix-sid index for the loopback interface (prefix-sid index 1 no-php).
- Assign appropriate prefix-sid index for flex algorithm for the same loopback interface
- Configure IS-IS for IPv4 on the loopback interface using the ip router isis command, specifying the IS-IS process ID (ip router isis 1).

```
RTR1(config)#interface loopback2
RTR1(config-if)# ip address 25.0.1.1/32 secondary
RTR1(config-if)# prefix-sid index 1
RTR1(config-if)# prefix-sid algorithm-num 128 index 1281
RTR1(config-if)# prefix-sid algorithm-num 129 index 1291
RTR1(config-if)# ip router isis 1
RTR1(config-if)# exit
```

Details of loopbacks

Router	Role	Loopbacks	loopback IP	Node SID	ALGO SID
RTR1	PE	Loopback1	25.0.0.1/32	NA	NA
		Loopback2	25.0.1.1/32	1	Algo 128: 1281 Algo 129: 1291
RTR2	P	Loopback1	25.0.1.1/32	NA	NA
		Loopback2	25.0.0.2/32	2	Algo 128: 1282 Algo 129: 1292
RTR3	PE	Loopback1	25.0.1.2/32	NA	NA
		Loopback2	25.0.0.3/32	3	Algo 128: 1283 Algo 129: 1293
RTR4	P	Loopback1	25.0.0.4/32	NA	NA
		Loopback2	25.0.1.4/32	4	Algo 128: 1284 Algo 129: 1294
RTR5	P,RR	Loopback1	25.0.0.5/32	NA	NA
		Loopback2	25.0.1.5/32	5	Algo 128: 1285 Algo 129: 1295
RTR6	P	Loopback1	25.0.0.6/32	NA	NA
		Loopback2	25.0.1.6/32	6	Algo 128: 1286 Algo 129: 1296

2. Configure network interface.

- Access interface configuration mode for the desired network interface (xe5, xe15 and xe22).
- Assign an IPv4 address to the network interface using the ipv4 address command followed by the desired

- IPv4 address and subnet mask (ip address 11.0.12.1/24).
- Configure the MTU for the interface (mtu 9216).
- Configure IS-IS for IPv4 on the interface using the IP router ISIS command, specifying the IS-IS process ID (ip router isis 1).

```
RTR1(config)#interface xe5
RTR1(config-if)# 11.0.12.1/24
RTR1(config-if)# mtu 9216
RTR1(config-if)# label-switching
RTR1(config-if)# ip router isis 1
RTR1(config-if)#exit
```

3. IS-IS and SR configuration.

- Configure I-IS metrics. Default IGP metric = 10.
- Configure IS-IS Level2 with wide metrics on all routers.
- Enable Segment Routing on all the routers.
- Advertise one Node-SID per router linked to loopback2 as described in the loopback addressing section.
- Configure new SRGB/SRLB range as follows:

```
RTR1(config)#segment-routing
RTR1(config-sr)# global block 20000 80000
```

Here additional details on IS-IS parameters:

- Remaining LSP lifetime = 65535 seconds
- LSP refresh (if configurable) = 65000 seconds
- LSP general interval = 1
- SPF interval exp 50 5000

```
RTR1(config)#router isis 1
RTR1(config-router)#is-type level-2-only
RTR1(config-router)#ignore-lsp-errors
RTR1(config-router)#lsp-gen-interval 1
RTR1(config-router)#max-lsp-lifetime 65535
RTR1(config-router)#spf-interval-exp 50 5000
RTR1(config-router)#metric-style wide
RTR1(config-router)#mpls traffic-eng router-id 25.0.1.1
RTR1(config-router)#mpls traffic-eng level-2
RTR1(config-router)#dynamic-hostname
RTR1(config-router)#net 49.0000.0100.0000.1011.00
RTR1(config-router)#isis segment-routing global block 20000 80000
RTR1(config-router)#segment-routing mpls
RTR1(config-router)#exit
```

4. Flex Algo Configuration:

All routers will be configured with the following algorithms:

- Algorithm 0: This uses standard SPF based on IGP metrics.
 - Default IGP metric: 10
- Algorithm 128: Designed to minimize TE metrics and include all links.
- Algorithm 129: Optimized for minimizing delay metrics and includes all links.
 - Delay metrics will be configured, and to ensure predictability, they may be static or dynamic depending on the test scenario.

```

RTR1(config)#router isis 1
RTR1(config-router)# capability flex-algo routing
RTR1(config-router)# flex-algo 128
RTR1(config-isis-fa)# metric-type te-metric
RTR1(config-isis-fa)# exit-flex-algo
RTR1(config-router)#exit
RTR1(config)#router isis 1
RTR1(config-router)# flex-algo 129
RTR1(config-isis-fa)# metric-type link-delay
RTR1(config-isis-fa)# exit-flex-algo

```

Link Attributes:

- Admin-Group Red: Assigned to bit position 1.
- Extended Admin-Group Green: Assigned to bit position 32
- Extended Admin-Group Blue: Assigned to bit position 93
- Te-metric as metric-type
- Link-delay as metric-type

```

RTR1(config)#
RTR1(config)#admin-group red 1
RTR1(config)#extended-admin-group green 32
RTR1(config)#extended-admin-group blue 93
RTR1(config)#int xe5
RTR1(config-if)# isis extended-admin-group flex-algo green
RTR1(config-if)# isis extended-admin-group flex-algo blue
RTR1(config-if)# isis te-metric flex-algo ipv4 225
RTR1(config-if)# isis te-minimum-delay flex-algo 10
RTR1(config-if)# isis te-maximum-delay flex-algo 20
RTR1(config-if)#exit

```

Flex-Algo Definition Advertisement:

- RTR2 acts as the primary node, advertising the Flex-Algo definition with a priority of 131.
- RTR5 serves as the backup node, advertising the Flex-Algo definition with a priority of 130.

```

RTR2(config-router)# flex-algo 128
RTR2(config-isis-fa)# priority 131
RTR2(config-isis-fa)# affinity-eag-include-any green
RTR2(config-isis-fa)# affinity-ag-exclude-any red
RTR2(config-isis-fa)# exit-flex-algo
RTR2(config-router)# flex-algo 129
RTR2(config-isis-fa)# priority 131
RTR2(config-isis-fa)# affinity-eag-include-all blue
RTR2(config-isis-fa)# affinity-ag-exclude-any orange
RTR2(config-isis-fa)# exit-flex-algo

```

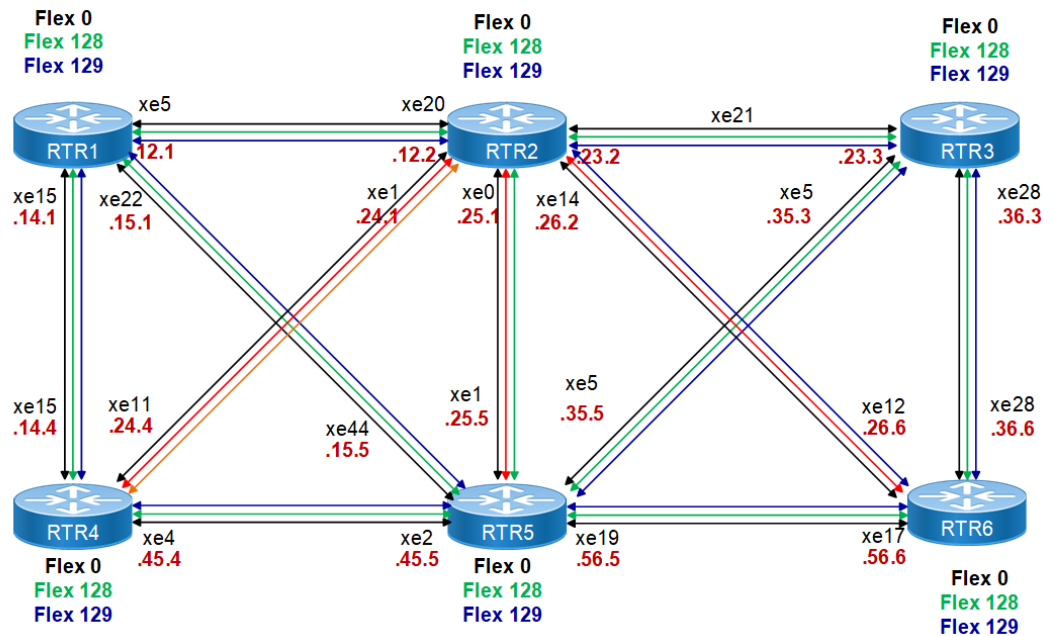
5. Enable TILFA for Flex-Algo 0, 128, and 129:

```

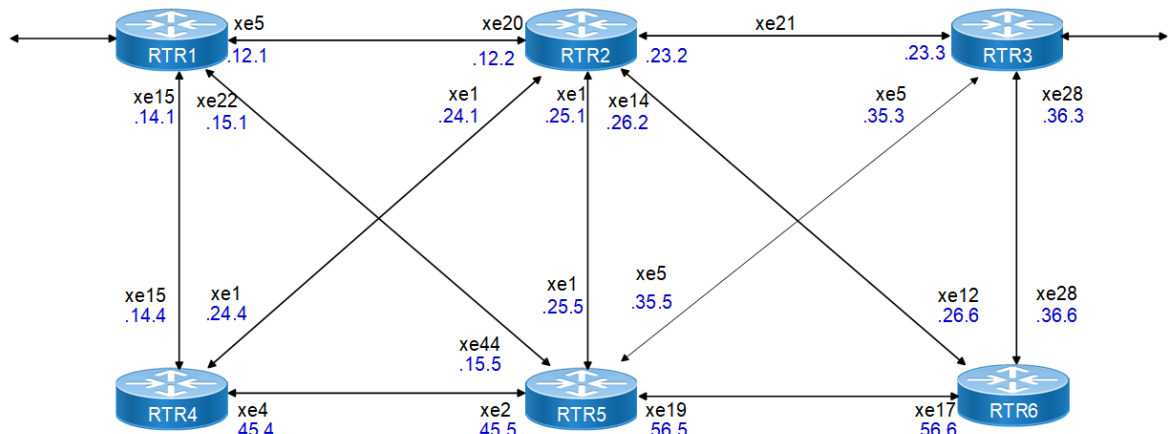
RTR2(config)#router isis 1
RTR2(config-router)#fast-reroute ti-lfa level-2 proto ipv4
RTR2(config-router)#flex-algo 128
RTR2(config-isis-fa)#ti-lfa
RTR2(config-isis-fa)#exit
RTR2(config-router)#flex-algo 129
RTR2(config-isis-fa)#ti-lfa
RTR2(config-isis-fa)#exit

```

Below are derived logical Topologies Based on Flexible Algorithms:

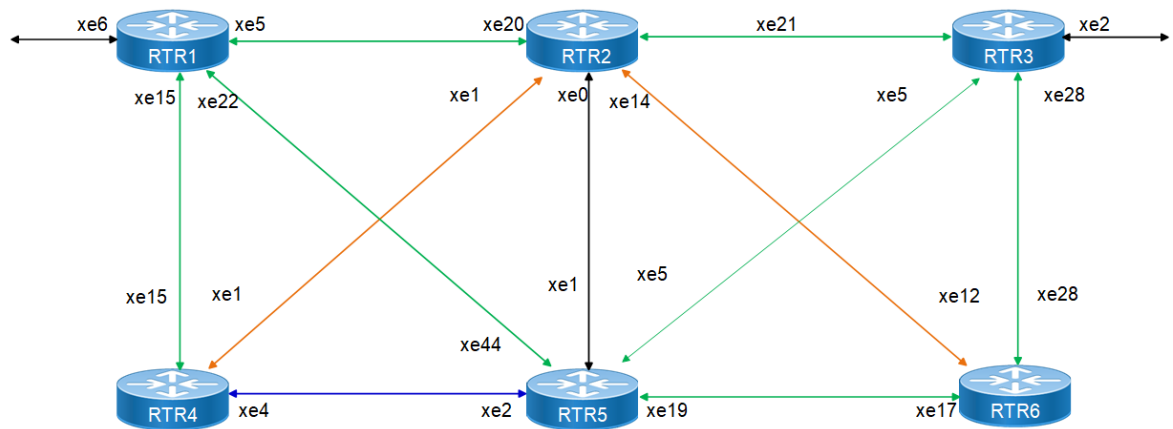
Figure 27. IGP Metric-Based Topology**Algorithm 0: Default IGP Metric-Based Topology**

- This topology adheres to the SPF computation using standard IGP metrics.
- The default IGP metric is as 10, unless explicitly modified.
- Logical representation: All routers and links contribute to a baseline network topology designed for general-purpose traffic forwarding.
- Use case: Ideal for non-critical, general traffic with no constraints or considerations.

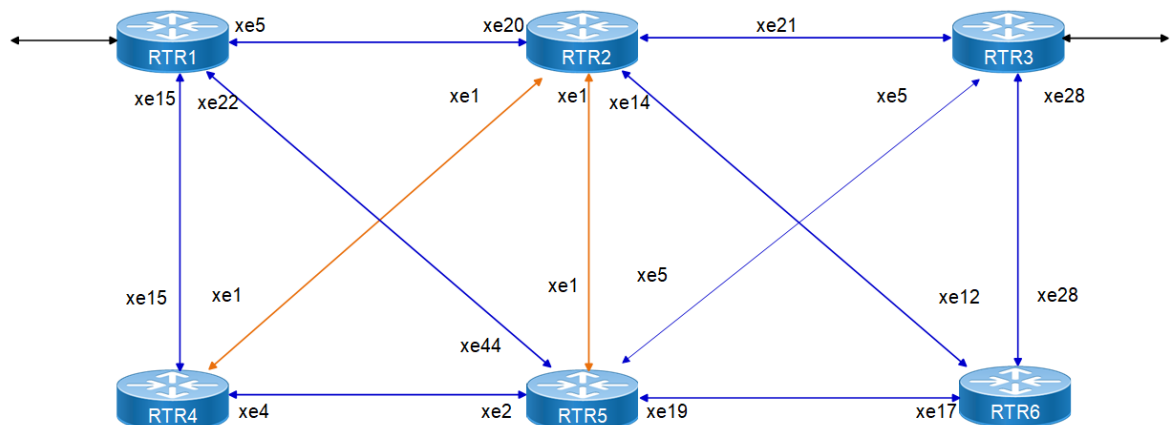
Figure 28. Flex Algo Zero**Algorithm 128: TE Metric-Optimized Topology (Minimizing TE Metrics)**

- Focuses on traffic engineering metrics and considers all links when computing paths.
- Logical topology is created based on configured TE metrics.
- Constraints for flex-algo 128 are Links with EAG GREEN are included links with AG RED are excluded.

- Example: Below scenario where specific links marked with a Green affinity are exclusively utilized to manage high-throughput services. All Red links are excluded.

Figure 29. FlexAlgo 128**Algorithm 129: Delay Metric-Optimized Topology (Minimizing Delay)**

- Constructs a topology optimized for minimizing delay metrics.
- Delay metrics are either dynamically monitored or configured statically to ensure test consistency.
- Logical paths are computed using the lowest cumulative delay across links, ensuring an efficient flow of delay-sensitive traffic.
- Constraints for flex-algo 129 are Links with EAG BLUE are included and links with AG ORANGE are excluded
- TWAMP is configured Between RTR1, RTR5, and RTR3 (forward direction) and static link-delay is configured in the reverse direction (RTR3, RTR5, and RTR1).
- Use case: Ideal for low-latency traffic flows, such as voice-over-IP (VoIP), live streaming, or critical 5G applications requiring minimal delay.
- Example: Below scenario where specific links marked with a BLUE; affinity are exclusively utilized to manage high-throughput services. All ORANGE links are excluded.

Figure 30. FlexAlgo 129

Configuration Sanapshot

RTR1

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)# ipv6 address 611::1/64	Configure the IPv6 address of the interface.
P4(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)# ipv6 address 511::2/64	Configure the IP address of the interface.
P4(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router OSPF area 0.
P4(config-if)#exit	Exit interface mode.
P4(config)#router ipv6 ospf 1	Set the routing process ID as 1
P4(config-router)#segment-routing srv6	Configure is-type as level-2
P4(config-router-af-srv6)#srv6-locator srs123	Name to SRv6 locator
P4(config-router)#exit	Exit router mode.

RTR2

Configuration Sanapshot of RTR2

```

!
qos enable
!
hostname RTR2
admin-group red 1
admin-group orange 2
extended-admin-group green 32
extended-admin-group blue 93
port-group 2 speed 10g
!
router-id 25.0.1.2
!
segment-routing
global block 20000 80000
!
interface loopback1
 ip address 25.0.0.2/32 secondary
 ip router isis 1
!
interface loopback2
 ip address 25.0.1.2/32 secondary
 prefix-sid index 2
 prefix-sid algorithm-num 128 index 1282
 prefix-sid algorithm-num 129 index 1292
 ip router isis 1
!

```

```
interface xe0
  load-interval 30
  ip address 11.0.25.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis admin-group flex-algo orange
  isis extended-admin-group flex-algo green
!
interface xel
  load-interval 30
  ip address 11.0.24.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis admin-group flex-algo red
  isis admin-group flex-algo orange
!
interface xe14
  load-interval 30
  ip address 11.0.26.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis admin-group flex-algo red
  isis extended-admin-group flex-algo blue
!
interface xe20
  load-interval 30
  ip address 11.0.12.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe21
  load-interval 30
  ip address 11.0.23.2/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
exit
!
router isis 1
```

```
is-type level-2-only
ignore-lsp-errors
capability flex-algo routing
flex-algo 128
  metric-type te-metric
  priority 131
  ti-lfa
  affinity-ag-exclude-any red
  affinity-eag-include-any green
exit-flex-algo
!
flex-algo 129
  metric-type link-delay
  priority 131
  ti-lfa
  affinity-ag-exclude-any orange
  affinity-eag-include-all blue
  exclude-maximum-delay 25
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.2
mpls traffic-eng level-2
dynamic-hostname
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0000.0100.0000.1022.00
isis segment-routing global block 20000 80000
segment-routing mpls
!
!
end
```

RTR3

Configuration Sanapshot of RTR3

```
!
hardware-profile filter twamp-ipv4 enable
!
qos enable
!
hostname RTR3
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
!
router-id 25.0.1.3
!
segment-routing
  global block 20000 80000
!
interface loopback1
  ip address 25.0.0.3/32 secondary
  ip router isis 1
!
interface loopback2
  ip address 25.0.1.3/32 secondary
  prefix-sid index 3
  prefix-sid algorithm-num 128 index 1283
  prefix-sid algorithm-num 129 index 1293
  ip router isis 1
!
```

```
interface xe5
  speed 10g
  load-interval 30
  ip address 11.0.35.3/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe21
  speed 10g
  load-interval 30
  ip address 11.0.23.3/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe28
  speed 10g
  load-interval 30
  ip address 11.0.36.3/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
exit
!
twamp-light reflector
  reflector-admin-state enable
  reflector-name R3-R5 reflector-ip ipv4 11.0.35.3 reflector-port 862 sender-ip ipv4 11.0.35.5
  sender-port 862
!
router isis 1
  is-type level-2-only
  ignore-lsp-errors
  capability flex-algo routing
  flex-algo 129
  metric-type link-delay
  ti-lfa
  exit-flex-algo
!
  flex-algo 128
  exit-flex-algo
!
  lsp-gen-interval 1
  max-lsp-lifetime 65535
  spf-interval-exp 50 5000
  metric-style wide
  mpls traffic-eng router-id 25.0.1.3
  mpls traffic-eng level-2
```

```
dynamic-hostname
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0000.0100.0000.1033.00
isis segment-routing global block 20000 80000
segment-routing mpls
!
router bgp 65010
  bgp router-id 25.0.1.3
  bgp auto-policy-soft-reset enable
  no bgp inbound-route-filter
  allocate-label all
  neighbor 25.0.0.5 remote-as 65010
  neighbor 25.0.0.5 update-source loopback1
  neighbor 25.0.1.5 remote-as 65010
  neighbor 25.0.1.5 update-source loopback2
  !
  address-family ipv4 unicast
  neighbor 25.0.0.5 activate
  exit-address-family
  !
  address-family vpnv4 unicast
  neighbor 25.0.1.5 activate
  exit-address-family
  !
exit
!
!
end
```

RTR4

Configuration Sanapshot of RTR4

```
RTR4#show running-config
qos enable
!
hostname RTR4
!
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
!
router-id 25.0.1.4
!
segment-routing
global block 20000 80000
!
interface loopback1
ip address 25.0.0.4/32 secondary
ip router isis 1
!
interface loopback2
ip address 25.0.1.4/32 secondary
prefix-sid index 4
prefix-sid algorithm-num 128 index 1284
prefix-sid algorithm-num 129 index 1294
ip router isis 1
!
interface xe1
speed 10g
load-interval 30
ip address 11.0.24.4/24
mtu 9216
label-switching
isis network point-to-point
```

```
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
!
interface xe4
load-interval 30
ip address 11.0.45.4/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
interface xe15
load-interval 30
ip address 11.0.14.4/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
exit
!
router isis 1
is-type level-2-only
ignore-lsp-errors
capability flex-algo routing
flex-algo 128
metric-type te-metric
exit-flex-algo
!
flex-algo 129
metric-type link-delay
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.4
mpls traffic-eng level-2
dynamic-hostname
set-overload-bit on-startup wait-for-bgp
bfd all-interfaces
net 49.0000.0100.0000.1044.00
isis segment-routing global block 20000 80000
segment-routing mpls
!
end
```

RTR5

Configuration Sanapshot of RTR5

```
!  
hardware-profile filter twamp-ipv4 enable  
!  
qos enable  
!  
hostname RTR5  
admin-group red 1  
admin-group orange 2  
extended-admin-group green 32  
extended-admin-group blue 93  
!  
delay-profile interfaces  
mode two-way  
burst-interval 1000  
burst-count 1  
interval 30  
advertisement periodic threshold 70  
advertisement periodic minimum-change 1000  
advertisement accelerated  
advertisement accelerated threshold 100  
advertisement accelerated minimum-change 10000  
!  
router-id 25.0.1.5  
!  
segment-routing  
global block 20000 80000  
!  
interface loopback1  
ip address 25.0.0.5/32 secondary  
ip router isis 1  
!  
interface loopback2  
ip address 25.0.1.5/32 secondary  
prefix-sid index 5  
prefix-sid algorithm-num 128 index 1285  
prefix-sid algorithm-num 129 index 1295  
ip router isis 1  
!  
interface xe1  
load-interval 30  
ip address 11.0.25.5/24  
mtu 9216  
label-switching  
isis network point-to-point  
ip router isis 1  
isis te-metric flex-algo ipv4 225  
isis te-minimum-delay flex-algo 20  
isis te-maximum-delay flex-algo 30  
isis admin-group flex-algo orange  
isis extended-admin-group flex-algo green  
!  
interface xe2  
load-interval 30  
ip address 11.0.45.5/24  
mtu 9216  
label-switching  
isis network point-to-point  
ip router isis 1  
isis te-metric flex-algo ipv4 225  
isis te-minimum-delay flex-algo 20  
isis te-maximum-delay flex-algo 30  
isis extended-admin-group flex-algo green  
isis extended-admin-group flex-algo blue  
!  
interface xe5  
load-interval 30  
ip address 11.0.35.5/24  
mtu 9216
```

```
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 225
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
delay-measurement dynamic twamp reflector-ip 11.0.35.3 reflector-port 862 sender-ip 11.0.35.5
sender-port 862
!
interface xe17
speed 10g
load-interval 30
mtu 9216
label-switching
shutdown
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 225
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo red
isis admin-group flex-algo anomaly red
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
interface xe19
load-interval 30
ip address 11.0.56.5/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 225
isis te-minimum-delay flex-algo 20
isis te-maximum-delay flex-algo 30
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
interface xe44
load-interval 30
ip address 11.0.15.5/24
mtu 9216
label-switching
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 225
isis te-minimum-delay flex-algo 20
isis te-maximum-delay flex-algo 30
isis extended-admin-group flex-algo green
isis extended-admin-group flex-algo blue
!
exit
!
twamp-light reflector
reflector-admin-state enable
reflector-name R1-R5 reflector-ip ipv4 11.0.15.5 reflector-port 862 sender-ip ipv4 11.0.15.1
sender-port 862
!
twamp-light control
control-admin-state enable
!
router isis 1
is-type level-2-only
ignore-lsp-errors
capability flex-algo routing
flex-algo 128
metric-type te-metric
```



```
priority 130
ti-lfa
exit-flex-algo
!
flex-algo 129
metric-type link-delay
ti-lfa
exit-flex-algo
!
lsp-gen-interval 1
max-lsp-lifetime 65535
spf-interval-exp 50 5000
metric-style wide
mpls traffic-eng router-id 25.0.1.5
mpls traffic-eng level-2
dynamic-hostname
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0000.0100.0000.1055.00
redistribute isis level-2 into level-1
isis segment-routing global block 20000 80000
segment-routing mpls
!
router bgp 65010
bgp router-id 25.0.1.5
bgp auto-policy-soft-reset enable
no bgp inbound-route-filter
allocate-label all
neighbor 25.0.0.1 remote-as 65010
neighbor 25.0.0.1 update-source loopback1
neighbor 25.0.0.3 remote-as 65010
neighbor 25.0.0.3 update-source loopback1
neighbor 25.0.1.1 remote-as 65010
neighbor 25.0.1.1 update-source loopback2
neighbor 25.0.1.3 remote-as 65010
neighbor 25.0.1.3 update-source loopback2
!
address-family ipv4 unicast
neighbor 25.0.0.1 activate
neighbor 25.0.0.3 activate
exit-address-family
!
address-family vpnv4 unicast
neighbor 25.0.1.1 activate
neighbor 25.0.1.1 route-reflector-client
neighbor 25.0.1.3 activate
neighbor 25.0.1.3 route-reflector-client
exit-address-family
!
exit
!
!
end
```

RTR6

Configuration Sanapshot of RTR6

```
!
qos enable
!
hostname RTR6
admin-group red 1
extended-admin-group green 32
extended-admin-group blue 93
!
```

```
router-id 25.0.1.6
!
segment-routing
  global block 20000 80000
!
interface loopback1
  ip address 25.0.0.6/32 secondary
  ip router isis 1
!
interface loopback2
  ip address 25.0.1.6/32 secondary
  prefix-sid index 6
  prefix-sid algorithm-num 128 index 1286
  prefix-sid algorithm-num 129 index 1296
  ip router isis 1
!
interface xel2
  load-interval 30
  ip address 11.0.26.6/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis admin-group flex-algo red
  isis extended-admin-group flex-algo blue
!
interface xel7
  load-interval 30
  ip address 11.0.56.6/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis extended-admin-group flex-algo green
  isis extended-admin-group flex-algo blue
!
interface xe28
  load-interval 30
  ip address 11.0.36.6/24
  mtu 9216
  label-switching
  isis network point-to-point
  ip router isis 1
  isis te-metric flex-algo ipv4 225
  isis te-minimum-delay flex-algo 20
  isis te-maximum-delay flex-algo 30
  isis extended-admin-group flex-algo blue
  isis extended-admin-group flex-algo green
!
exit
!
router isis 1
  is-type level-2-only
  ignore-lsp-errors
  capability flex-algo routing
  flex-algo 128
  metric-type te-metric
  ti-lfa
  exit-flex-algo
!
  flex-algo 129
  metric-type link-delay
```

```

    ti-lfa
    exit-flex-algo
    !
    lsp-gen-interval 1
    max-lsp-lifetime 65535
    spf-interval-exp 50 5000
    metric-style wide
    mpls traffic-eng router-id 25.0.1.6
    mpls traffic-eng level-2
    dynamic-hostname
    fast-reroute ti-lfa level-2 proto ipv4
    bfd all-interfaces
    net 49.0000.0100.0000.1066.00
    isis segment-routing global block 20000 80000
    segment-routing mpls
    !
    !
end

```

Validation

Verify the isis adjacencies are established and the routes are displaying correctly

```
RTR1#show clns neighbors
```

```
Total number of L1 adjacencies: 0
```

```
Total number of L2 adjacencies: 3
```

```
Total number of adjacencies: 3
```

```
Tag 1: VRF : default
```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
RTR2	xe5	e8c5.7a2e.5631	Up	23	L2	IS-IS
RTR4	xe15	3412.7856.011c	Up	19	L2	IS-IS
RTR5	xe22	80a2.353a.b78e	Up	22	L2	IS-IS

```
RTR1#
```

```
RTR1#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 1: VRF : default
```

```
Total number of routes: 23
```

	Destination	Metric	Next-Hop	Interface	Tag
C	11.0.12.0/24	10	--	xe5	0
C	11.0.14.0/24	10	--	xe15	0
C	11.0.15.0/24	10	--	xe22	0
L2	11.0.23.0/24	20	11.0.12.2	xe5	0
L2	11.0.24.0/24	20	11.0.14.4	xe15	0
			11.0.12.2	xe5	0
L2	11.0.25.0/24	20	11.0.12.2	xe5	0
			11.0.15.5	xe22	0
L2	11.0.26.0/24	20	11.0.12.2	xe5	0
L2	11.0.35.0/24	20	11.0.15.5	xe22	0
L2	11.0.36.0/24	30	11.0.12.2	xe5	0
			11.0.15.5	xe22	0
L2	11.0.45.0/24	20	11.0.14.4	xe15	0
			11.0.15.5	xe22	0
L2	11.0.56.0/24	20	11.0.15.5	xe22	0
C	25.0.0.1/32	10	--	loopback1	0
L2	25.0.0.2/32	20	11.0.12.2	xe5	0
L2	25.0.0.3/32	30	11.0.12.2	xe5	0
			11.0.15.5	xe22	0

L2	25.0.0.4/32	20	11.0.14.4	xe15	0
L2	25.0.0.5/32	20	11.0.15.5	xe22	0
L2	25.0.0.6/32	30	11.0.12.2	xe5	0
			11.0.15.5	xe22	0
C	25.0.1.1/32	10	--	loopback2	0
L2	25.0.1.2/32	20	11.0.12.2	xe5	0
L2	25.0.1.3/32	30	11.0.12.2	xe5	0
			11.0.15.5	xe22	0
L2	25.0.1.4/32	20	11.0.14.4	xe15	0
L2	25.0.1.5/32	20	11.0.15.5	xe22	0
L2	25.0.1.6/32	30	11.0.12.2	xe5	0
			11.0.15.5	xe22	0

Verify the SR capability and its mapping table to check the mapping of the prefixes to algorithm and the prefix-sid

```
RTR1#show isis segment-routing capability

Tag 1 Segment-Routing:
-----
Advertisement Router Capability :25.0.1.1
Algorithm0                     :0
Algorithm1                     :129
Algorithm2                     :128
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :10
SID Range List Count           :1
SID's Range                    :20000 - 80000
Total SID's Supported (SRLB)   :1920
SRLB Range List Count          :1
SID's Range (SRLB)             :14080 - 15999
-----
Advertisement Router Capability :25.0.1.2
Algorithm0                     :0
Algorithm1                     :128
Algorithm2                     :129
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :20000 - 80000
Total SID's Supported (SRLB)   :1920
SRLB Range List Count          :1
SID's Range (SRLB)             :14080 - 15999
-----
Advertisement Router Capability :25.0.1.3
Algorithm0                     :0
Algorithm1                     :129
Algorithm2                     :128
SRMS Preference                :0
Total SID'S Supported          :60001
SR ERLD                        :10
SID Range List Count           :1
SID's Range                    :20000 - 80000
Total SID's Supported (SRLB)   :1920
SRLB Range List Count          :1
SID's Range (SRLB)             :14080 - 15999
-----
Advertisement Router Capability :25.0.1.4
Algorithm0                     :0
Algorithm1                     :128
Algorithm2                     :129
SRMS Preference                :0
Total SID'S Supported          :60001
```

```

SR ERLD :6
SID Range List Count :1
SID's Range :20000 - 80000
Total SID's Supported (SRLB) :1920
SRLB Range List Count :1
SID's Range (SRLB) :14080 - 15999
-----
Advertisement Router Capability :25.0.1.5
Algorithm0 :0
Algorithm1 :128
Algorithm2 :129
SRMS Preference :0
Total SID'S Supported :60001
SR ERLD :6
SID Range List Count :1
SID's Range :20000 - 80000
Total SID's Supported (SRLB) :1920
SRLB Range List Count :1
SID's Range (SRLB) :14080 - 15999
-----
Advertisement Router Capability :25.0.1.6
Algorithm0 :0
Algorithm1 :128
Algorithm2 :129
SRMS Preference :0
Total SID'S Supported :60001
SR ERLD :6
SID Range List Count :1
SID's Range :20000 - 80000
Total SID's Supported (SRLB) :1920
SRLB Range List Count :1
SID's Range (SRLB) :14080 - 15999

RTR1#show isis segment-routing mapping-table ipv
ipv4 ipv6
RTR1#show isis segment-routing mapping-table ipv4 active
Tag 1 Segment-Routing:
Conflict Resolution Policy: Quarantine

Prefix          Range      Flags      Algo/SID-Index/Prefix-Flag List
25.0.1.1/32      1          Algo:0    SID:1      PF:40
                Algo:128  SID:1281  PF:40
                Algo:129  SID:1291  PF:40
25.0.1.2/32      1          Algo:0    SID:2      PF:40
                Algo:128  SID:1282  PF:40
                Algo:129  SID:1292  PF:40
25.0.1.3/32      1          Algo:0    SID:3      PF:40
                Algo:128  SID:1283  PF:40
                Algo:129  SID:1293  PF:40
25.0.1.4/32      1          Algo:0    SID:4      PF:40
                Algo:128  SID:1284  PF:40
                Algo:129  SID:1294  PF:40
25.0.1.5/32      1          Algo:0    SID:5      PF:40
                Algo:128  SID:1285  PF:40
                Algo:129  SID:1295  PF:40
25.0.1.6/32      1          Algo:0    SID:6      PF:40
                Algo:128  SID:1286  PF:40
                Algo:129  SID:1296  PF:40

Number of mapping entries in Active IPv4 Table: 6

```

Verify the forwarding table for algo 0 and for the prefix 25.0.1.3/32 (destination)

```

RTR1#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: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
i>	25.0.1.2/32	9	358	-	-	-	-
	-	128	00:20:40	6	0	Yes 3	xe5 No
	11.0.12.2	-	-	357	-	-	-
	No	21282	xe22	No	11.0.15.5	-	-
i>	25.0.1.2/32	5	435	-	-	-	-
	-	129	00:12:05	6	0	Yes 3	xe5 No
	11.0.12.2	-	-	434	-	-	-
	No	21292	xe22	No	11.0.15.5	-	-
i>	25.0.1.2/32	1	415	-	-	-	-
	-	0	00:20:40	6	0	Yes 3	xe5 No
	11.0.12.2	-	-	414	-	-	-
	No	20002	xe15	No	11.0.14.4	-	-
i							
(b)>	25.0.1.2/32	17	352	2202	Yes	21282	xe5 No
	11.0.12.2	128	00:12:03				
i							
(b)>	25.0.1.2/32	19	355	2204	Yes	20002	xe5 No
	11.0.12.2	0	00:12:03				
i>	25.0.1.3/32	10	360	-	-	-	-
	-	128	00:20:40	111	0	Yes 21283	xe5 No
	11.0.12.2	-	-	31	-	-	-
	No	21283	xe22	No	11.0.15.5	-	-
	11.0.15.5	-	-	31	0	Yes 21283	xe22 No
	No	21283	xe5	No	11.0.12.2	-	-
i>	25.0.1.3/32	6	437	-	-	-	-
	-	129	00:12:05	421	0	Yes 21293	xe22 No
	11.0.15.5	-	-	6	-	-	-
	No	3	xe5	No	11.0.12.2	-	-
i>	25.0.1.3/32	2	372	-	-	-	-
	-	0	00:20:40	102	0	Yes 20003	xe5 No
	11.0.12.2	-	-	22	-	-	-
	No	20003	xe22	No	11.0.15.5	-	-
	11.0.15.5	-	-	22	0	Yes 20003	xe22 No
	No	20003	xe5	No	11.0.12.2	-	-
i							
(b)>	25.0.1.3/32	27	164	2212	Yes	21293	xe5 No
	11.0.12.2	129	00:09:50				
i>	25.0.1.4/32	11	397	-	-	-	-
	-	128	00:20:40	1	0	Yes 3	xe15 No
	11.0.14.4	-	-	244	-	-	-
	No	21284	xe22	No	11.0.15.5	-	-
i>	25.0.1.4/32	7	440	-	-	-	-
	-	129	00:12:05	1	0	Yes 3	xe15 No
	11.0.14.4	-	-	439	-	-	-

	No	21294	xe22	No	11.0.15.5	-	-	-
i>	25.0.1.4/32	3	432	-	-	-	-	-
	-	0	00:20:40					
	11.0.14.4	-	1	0	Yes	3	xe15	No
			87	-				
	No	20004	xe5	No	11.0.12.2	-	-	
i								
(b)>	25.0.1.4/32	24	393	2209	Yes	21284	xe15	No
	11.0.14.4	128	00:11:46					
i								
(b)>	25.0.1.4/32	25	395	2210	Yes	20004	xe15	No
	11.0.14.4	0	00:11:46					
i								
(b)>	25.0.1.4/32	28	109	2213	Yes	21294	xe15	No
	11.0.14.4	129	00:09:50					
i>	25.0.1.5/32	12	399	-	-	-	-	-
	-	128	00:20:40					
	11.0.15.5	-	13	0	Yes	3	xe22	No
			181	-				
	No	21285	xe15	No	11.0.14.4	-	-	
i>	25.0.1.5/32	8	442	-	-	-	-	-
	-	129	00:12:05					
	11.0.15.5	-	13	0	Yes	3	xe22	No
			85	-				
	No	21295	xe15	No	11.0.14.4	-	-	
i>	25.0.1.5/32	4	419	-	-	-	-	-
	-	0	00:20:40					
	11.0.15.5	-	13	0	Yes	3	xe22	No
			188	-				
	No	20005	xe15	No	11.0.14.4	-	-	
i								
(b)>	25.0.1.5/32	16	350	2201	Yes	21285	xe22	No
	11.0.15.5	128	00:12:03					
i								
(b)>	25.0.1.5/32	18	37	2203	Yes	20005	xe22	No
	11.0.15.5	0	00:12:03					
i								
(b)>	25.0.1.5/32	26	428	2211	Yes	21295	xe22	No
	11.0.15.5	129	00:09:50					
i>	25.0.1.6/32	15	367	-	-	-	-	-
	-	128	00:20:40					
	11.0.15.5	-	34	0	Yes	21286	xe22	No
			171	-				
	No	21286	xe5	No	11.0.12.2	-	-	
i>	25.0.1.6/32	14	444	-	-	-	-	-
	-	129	00:12:05					
	11.0.15.5	-	28	0	Yes	21296	xe22	No
			6	-				
	No	3	xe5	No	11.0.12.2	-	-	
i>	25.0.1.6/32	13	378	-	-	-	-	-
	-	0	00:20:40					
	11.0.12.2	-	105	0	Yes	20006	xe5	No
			25	-				
	No	20006	xe22	No	11.0.15.5	-	-	
	11.0.15.5	-	25	0	Yes	20006	xe22	No
			105	-				
	No	20006	xe5	No	11.0.12.2	-	-	
i								
(b)>	25.0.1.6/32	22	59	2207	Yes	21296	xe5	No
	11.0.12.2	129	00:11:46					

```

RTR1#show mpls forwarding-table 25.0.1.3/32
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: Disabled
Code   FEC          FTN-ID  Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC          Nexthop Algo-Num  UpTime
i>     25.0.1.3/32    10      360       -          -    -          -
      -            128      00:21:24
      111          0          Yes    21283     xe5        No
11.0.12.2  -          -          31       -          -    -          -
      No          21283     xe22      No        11.0.15.5  -          -
      31          0          Yes    21283     xe22        No
11.0.15.5  -          -          111      -          -    -          -
      No          21283     xe5       No        11.0.12.2  -          -
i>     25.0.1.3/32    6        437       -          -    -          -
      -            129      00:12:49
      421         0          Yes    21293     xe22        No
11.0.15.5  -          -          6        -          -    -          -
      No          3        xe5       No        11.0.12.2  -          -
i>     25.0.1.3/32    2        372       -          -    -          -
      -            0        00:21:24
      102         0          Yes    20003     xe5        No
11.0.12.2  -          -          22       -          -    -          -
      No          20003     xe22      No        11.0.15.5  -          -
      22         0          Yes    20003     xe22        No
11.0.15.5  -          -          102      -          -    -          -
      No          20003     xe5       No        11.0.12.2  -          -
i
(b)>     25.0.1.3/32    27       164       2212      Yes    21293     xe5        No
11.0.12.2  129      00:10:34

```

Verify the FAD of the winner node for flex-algo 128:

```

RTR1#show isis flex-algo 128 status winner detail
ISIS Instance : 1
Router-ID : 25.0.1.2, System-ID : 0100.0000.1022
Algorithm Number : 128
Metric Type : te-metric
Calculation Type : spf
Priority : 131 (Winner)
Prefix Metric Flag : No
Fwd-Exclude-Any-AG Mask :
(1)
Fwd-Include-Any-AG Mask : None
Fwd-Include-All-AG Mask : None
Rev-Exclude-Any-AG Mask : None
Rev-Include-Any-AG Mask : None
Rev-Include-All-AG Mask : None
Fwd-Exclude-Any-EAG Mask :
(1)
Fwd-Include-Any-EAG Mask :
(32)
Fwd-Include-All-EAG Mask : NULL
Rev-Exclude-Any-EAG Mask : NULL
Rev-Include-Any-EAG Mask : NULL
Rev-Include-All-EAG Mask : NULL
Exclude SRLG-ID List : NULL
Exclude Minimum Bandwidth : 0

```



```

Exclude Maximum Delay      : 0
Intf-Group Mode Total B/W Calculate : No
Reference Bandwidth : 0
Granularity Bandwidth : 0

```

Verify the isis topology and forwarding-table for algorithm 128 are as per the configurations of FAD in the winner node:

```
RTR1#show isis topology algorithm 128
```

```
Tag 1: VRF : default
```

```
Flex-Algo : 128
```

```
IS-IS paths to level-2 routers
```

System Id	Metric	Next-Hop	Interface	SNPA
RTR1	--			
RTR2	225	RTR2 xe5	e8c5.7a2e.5631	
RTR3	450	RTR2 xe5	e8c5.7a2e.5631	
		RTR5 xe22	80a2.353a.b78e	
RTR4	225	RTR4 xe15	3412.7856.011c	
RTR5	225	RTR5 xe22	80a2.353a.b78e	
RTR6	450	RTR5 xe22	80a2.353a.b78e	

```
RTR1#show mpls forwarding-table algorithm
```

```
RTR1#show mpls forwarding-table algorithm 128
```

```

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: Disabled
```

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
i>	25.0.1.2/32	9	358	-	-	-	-
	-	128	00:24:42				
	11.0.12.2	-	6	0	Yes	3	xe5
	No	21282	357	-			No
					11.0.15.5	-	-
i							
(b)>	25.0.1.2/32	17	352	2202	Yes	21282	xe5
	11.0.12.2	128	00:16:05				No
i>	25.0.1.3/32	10	360	-	-	-	-
	-	128	00:24:42				
	11.0.12.2	-	111	0	Yes	21283	xe5
	No	21283	31	-			No
					11.0.15.5	-	-
	11.0.15.5	-	31	0	Yes	21283	xe22
	No	21283	111	-			No
					11.0.12.2	-	-
i>	25.0.1.4/32	11	397	-	-	-	-
	-	128	00:24:42				
	11.0.14.4	-	1	0	Yes	3	xe15
	No	21284	244	-			No
					11.0.15.5	-	-
i							
(b)>	25.0.1.4/32	24	393	2209	Yes	21284	xe15
	11.0.14.4	128	00:15:48				No
i>	25.0.1.5/32	12	399	-	-	-	-
	-	128	00:24:42				
	11.0.15.5	-	13	0	Yes	3	xe22
	No	21285	181	-			No
					11.0.14.4	-	-

```

i
(b)> 25.0.1.5/32      16      350      2201      Yes  21285      xe22      No
      11.0.15.5      128      00:16:05
i> 25.0.1.6/32      15      367      -      -      -      -      -
      -      128      00:24:42
      11.0.15.5      -      -      34      0      Yes  21286      xe22      No
      No      21286      xe5      171      -      11.0.12.2      -      -
      No      21286      xe5      No      11.0.12.2      -      -

RTR1#show mpls forwarding-table 25.0.1.3/32 algorithm 128
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: Disabled
Code   FEC          FTN-ID   Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC          Nexthop   Algo-Num  UpTime
i> 25.0.1.3/32    10      360      -          -      -      -      -
      -      128      00:25:48
      11.0.12.2    -      -      111      0      Yes  21283      xe5      No
      No      21283      xe22      No      11.0.15.5    -      -      -
      11.0.15.5    -      -      31      0      Yes  21283      xe22      No
      No      21283      xe5      No      11.0.12.2    -      -

```

Verify the P, Q and PQ nodes are as the per the topology of flex-algo 128:

```

RTR1#show isis tilfa pq algorithm 128

Tag 1: Level-2 Link State Database:
Flex-Algo : 128

Node: RTR2.00-00
Interface xe5
P node: 0100.0000.1022 primary dist:450
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225
P node: 0100.0000.1055 primary dist:225
P node: 0100.0000.1066 primary dist:450
Q node: 0100.0000.1022
Q node: 0100.0000.1033
Q node: 0100.0000.1055
Q node: 0100.0000.1066
Node Protecting P Nodes
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225
P node: 0100.0000.1055 primary dist:225
P node: 0100.0000.1066 primary dist:450

PQ Node: RTR5.00-00 backup dist:10
No PQ Node found on backup path (Node Protection)

Node: RTR3.00-00
Interface xe5
P node: 0100.0000.1022 primary dist:450
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225
P node: 0100.0000.1055 primary dist:225
P node: 0100.0000.1066 primary dist:450
Q node: 0100.0000.1022
Q node: 0100.0000.1033

```

```
Q node: 0100.0000.1055
Q node: 0100.0000.1066
Node Protecting P Nodes
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225
P node: 0100.0000.1055 primary dist:225
P node: 0100.0000.1066 primary dist:450

PQ Node: RTR5.00-00 backup dist:10
PQ Node (Node Protection): RTR5.00-00 backup dist:10
Interface xe22
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225
P node: 0100.0000.1055 primary dist:450
P node: 0100.0000.1066 primary dist:675
Q node: 0100.0000.1022
Q node: 0100.0000.1033
Q node: 0100.0000.1044
Q node: 0100.0000.1055
Q node: 0100.0000.1066
Node Protecting P Nodes
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225

PQ Node: RTR2.00-00 backup dist:10
PQ Node (Node Protection): RTR2.00-00 backup dist:10

Node: RTR4.00-00
Interface xe15
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:450
P node: 0100.0000.1055 primary dist:225
P node: 0100.0000.1066 primary dist:450
Q node: 0100.0000.1033
Q node: 0100.0000.1044
Q node: 0100.0000.1055
Q node: 0100.0000.1066
Node Protecting P Nodes
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1055 primary dist:225
P node: 0100.0000.1066 primary dist:450

PQ Node: RTR5.00-00 backup dist:10
No PQ Node found on backup path (Node Protection)

Node: RTR5.00-00
Interface xe22
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225
P node: 0100.0000.1055 primary dist:450
P node: 0100.0000.1066 primary dist:675
Q node: 0100.0000.1022
Q node: 0100.0000.1033
Q node: 0100.0000.1044
Q node: 0100.0000.1055
Q node: 0100.0000.1066
Node Protecting P Nodes
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225

PQ Node: RTR4.00-00 backup dist:10
No PQ Node found on backup path (Node Protection)
```

```

Node: RTR6.00-00
Interface xe22
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225
P node: 0100.0000.1055 primary dist:450
P node: 0100.0000.1066 primary dist:675
Q node: 0100.0000.1022
Q node: 0100.0000.1033
Q node: 0100.0000.1044
Q node: 0100.0000.1055
Q node: 0100.0000.1066
Node Protecting P Nodes
P node: 0100.0000.1022 primary dist:225
P node: 0100.0000.1033 primary dist:450
P node: 0100.0000.1044 primary dist:225

PQ Node: RTR4.00-00 backup dist:10
PQ Node (Node Protection): RTR2.00-00 backup dist:10
RTR1#
RTR1#
RTR1#show ip isis route tilfa algorithm 128

Tag      : 1   VRF : default
Flex-Algo : 128
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2,
        C - Connected Routes, ia - IS-IS inter area

25.0.1.2/32
Route type: L2, FTN-ix :9   ILM-ix :15
SR Incoming Label      : 21282
Primary Path Nexthop   : 11.0.12.2, xe5
SR outgoing Label      : 3
PQ node                : 25.0.1.5
Backup outgoing Label: 21282
Bypass_trunk id        : 2201
Backup out interface   : xe22
Protection Type        : Link Protecting

Trunk : 2202 :25.0.1.2_nh_10026_ALG128   FTN-ix : 17 ref_cnt:2
Number Of outgoing label : 1
21282
Nexthop address : 11.0.12.2

25.0.1.3/32
Route type: L2, FTN-ix :10  ILM-ix :16
SR Incoming Label      : 21283
Primary Path Nexthop   : 11.0.12.2, xe5
SR outgoing Label      : 21283
PQ node                : 25.0.1.5
Backup outgoing Label: 21283
Bypass_trunk id        : 2201
Backup out interface   : xe22
Protection Type        : Node Protecting
Primary Path Nexthop   : 11.0.15.5, xe22
SR outgoing Label      : 21283
PQ node                : 25.0.1.2
Backup outgoing Label: 21283
Bypass_trunk id        : 2202
Backup out interface   : xe5
Protection Type        : Node Protecting

25.0.1.4/32
Route type: L2, FTN-ix :11  ILM-ix :17
SR Incoming Label      : 21284

```

```
Primary Path Nexthop   : 11.0.14.4, xe15
SR outgoing Label     : 3
PQ node               : 25.0.1.5
Backup outgoing Label : 21284
Bypass_trunk id       : 2201
Backup out interface   : xe22
Protection Type        : Link Protecting

Trunk : 2209 :25.0.1.4_nh_10036_ALG128   FTN-ix : 24 ref_cnt:1
Number Of outgoing label : 1
21284
Nexthop address : 11.0.14.4
```

25.0.1.5/32

```
Route type: L2, FTN-ix :12  ILM-ix :18
SR Incoming Label      : 21285
Primary Path Nexthop   : 11.0.15.5, xe22
SR outgoing Label      : 3
PQ node               : 25.0.1.4
Backup outgoing Label : 21285
Bypass_trunk id       : 2209
Backup out interface   : xe15
Protection Type        : Link Protecting

Trunk : 2201 :25.0.1.5_nh_10043_ALG128   FTN-ix : 16 ref_cnt:3
Number Of outgoing label : 1
21285
Nexthop address : 11.0.15.5
```

25.0.1.6/32

```
Route type: L2, FTN-ix :15  ILM-ix :21
SR Incoming Label      : 21286
Primary Path Nexthop   : 11.0.15.5, xe22
SR outgoing Label      : 21286
PQ node               : 25.0.1.2
Backup outgoing Label : 21286
Bypass_trunk id       : 2202
Backup out interface   : xe5
Protection Type        : Node Protecting
```

Flexible Algorithm for ISIS with SRLG

Overview

Flexible Algorithm allows Interior gateway Protocols (IGP) to calculate additional best paths based on specified constraints, thereby providing simple traffic engineering without using a network controller. Shared Risk Link Group (SRLG) provides an indication of which links in the network might be at risk from the same failure, and allows specifying such links to be excluded during Flex-Algo path computation.

Shared Risk Link Groups (SRLG) Disjoint Backup Path: This feature protects traffic against failure of a group of links that share the same risk of failure. This allows the setup of disjoint path(s) for each specific default-Algo or Flex-Algo by leveraging deployed SRLG configurations. It facilitates resiliency against failure of any links along the primary path(s).

This is an enhancement to Topology Independent Loop-Free Alternate (TI-LFA) based calculations of backup path(s) that provides fast reroute protection (FRR), minimizes downtime, and provides re-convergence on failure detection.

Flexible Algorithm Exclude SRLG Constraints: This feature computes flexible algorithm specific path(s) that avoid links with the same risk that an operator intends these path(s) to avoid. When Exclude SRLG Constraints are configured for a Flexible Algorithm definition, the computed path(s) do not transverse any links that advertise the same SRLG(s) as included in the specific Flexible Algorithm definition.

The Exclude SRLG constraints based link pruning only applies to Flexible algorithm specific path(s), and to both primary and backup path(s) during Constrained Shortest Path First (CSPF) base path computation procedures.

Feature Characteristics

- Multiple Flex Algo(s) can be defined by excluding different sets of SRLGs. Each Flex-Algo prunes the links belonging to the excluded SRLGs from its topology on which it computes its paths.
- Provides a new alternative to creating disjoint paths for Flex-Algo, in addition to leveraging the link's admin-group, extended-admin-group, or maximum delay constraints as Flex-Algo constraints.
- When computing the shortest path tree for particular Flexible Algorithm:
 - All nodes that do not advertise support for such Flexible Algorithm are pruned from the topology.
 - If the Flexible Algorithm definition includes "Exclude SRLG(s)", then all links where such SRLG(s) are advertised are pruned from the topology.
 - For ISIS, TI-LFA backup paths for a Flexible Algorithm are computed using the same constraints as the calculation of the primary paths. Additionally, flexible algorithm specific backup paths that are TI-LFA calculated can be SRLG disjoint. This means the primary path and backup path do not share any common SRLG(s).

Limitations

In Flexible Algorithm Specific Link Attributes (ASLA) SRLG TLV, the following are not supported:

- Advertisement is not supported for IPv6 and unnumbered ISIS interfaces.
- Decoding is not supported for IPv6 and unnumbered ISIS interfaces.

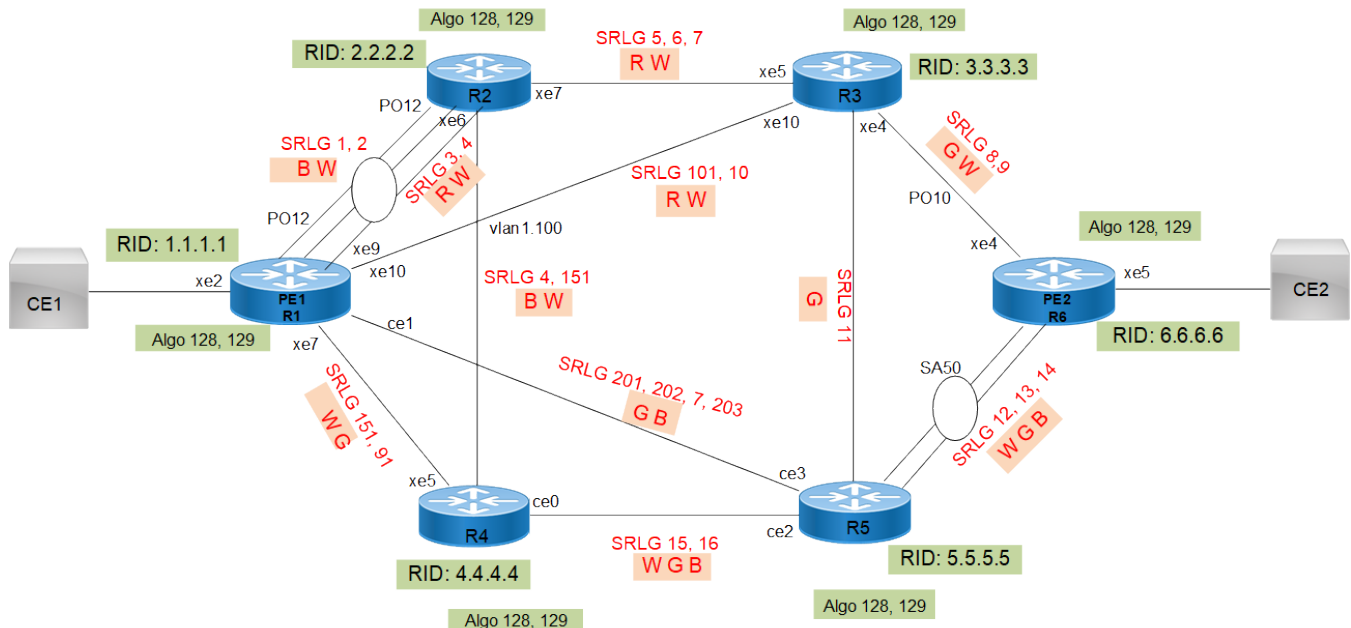
Configuration

Topology

In the below topology, a primary label-switched path (LSP) from router R1 to router R5 is protected against the failure of the R2-R9 link at R2 via a backup tunnel to R4.

If the R2-R9 link fails, SRLG disjoint protection reroutes the LSP along the backup tunnel. The backup LSP follows the links R2-R6, R6-R7, R7-R8 and R8-R4 which are not a part of the SRLG(s) in the primary path. Hence if the R2-R9 link fails, the traffic will fail over to backup the label-switched path.

Figure 31. Flex-Algo TI-LFA SRLG Disjoint Backup Path



To configure ISIS and link SRLG configurations, follow the steps mentioned below:

R1

1. Configure prefix-sid.

```
interface lo
 ip address 127.0.0.1/8
 ip address 1.1.1.1/32 secondary
 ipv6 address ::1/128
 prefix-sid index 101 no-php
 prefix-sid algorithm-num 128 index 1
 prefix-sid algorithm-num 129 index 11 no-php
 ip router isis 1
!
```

2. Configure interface SRLG.

```
interface po12
 load-interval 30
 ip address 10.12.12.1/24
 mtu 9216
```

```

label-switching
mpls traffic-eng srlg 501 ----> legacy SRLG configuration
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo white
isis admin-group flex-algo blue
isis srlg flex-algo 1 -----> ASLA SRLG configuration
isis srlg flex-algo 2
isis srlg flex-algo 5001
isis srlg flex-algo 5002
isis srlg flex-algo 5003
!
interface xe9
speed 10g
load-interval 30
ip address 10.10.12.1/24
mtu 9216
label-switching
mpls traffic-eng srlg 503
mpls traffic-eng srlg 34
mpls traffic-eng srlg 15001
adjacency-sid isis absolute 42151
ip ospf network point-to-point
ip ospf cost 2
isis network point-to-point
ip router isis 1
isis wide-metric 50
isis te-metric flex-algo ipv4 50
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo red
isis admin-group flex-algo white
isis srlg flex-algo 1
isis srlg flex-algo 3
isis srlg flex-algo 4
!
interface xe10
speed 10g
load-interval 30
ip address 10.10.13.1/24
mtu 9216
label-switching
mpls traffic-eng srlg 609
mpls traffic-eng srlg 268
mpls traffic-eng srlg 505
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 15
isis te-maximum-delay flex-algo 15
isis admin-group flex-algo white
isis admin-group flex-algo red
isis srlg flex-algo 509
isis srlg flex-algo 101
isis srlg flex-algo 10
!
!
interface cel
load-interval 30

```



```

ip address 10.10.15.1/24
mtu 9216
label-switching
mpls traffic-eng srlg 505
mpls traffic-eng srlg 503
mpls traffic-eng srlg 512
mpls traffic-eng srlg 15001
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis wide-metric 35
isis te-metric flex-algo ipv4 35
isis te-minimum-delay flex-algo 20
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo green
isis admin-group flex-algo blue
isis srlg flex-algo 201
isis srlg flex-algo 202
isis srlg flex-algo 203
isis srlg flex-algo 207
!
!
interface xe7.101
encapsulation dot1q 14
load-interval 30
ip address 10.10.14.1/24
ip address 10.14.15.1/24 secondary
label-switching
admin-group blue
mpls traffic-eng srlg 6
mpls traffic-eng srlg 10
mpls traffic-eng srlg 551
mpls traffic-eng srlg 552
mpls traffic-eng srlg 15001
adjacency-sid isis index 14
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis wide-metric 20
isis te-metric flex-algo ipv4 20
isis te-minimum-delay flex-algo 10
isis te-maximum-delay flex-algo 10
isis admin-group flex-algo green
isis srlg flex-algo 151
isis srlg flex-algo 91
isis srlg flex-algo 5003
isis srlg flex-algo 5002
isis srlg flex-algo 5001

```

3. Configure service interface.

```

!
interface xe2.101
encapsulation dot1q 101
load-interval 30
ip vrf forwarding VPN101
ip address 100.7.1.1/24
ipv6 address 101::1/64
mtu 9216
!
!
DUT1#sh run int xe2.102
!
interface xe2.102

```

```
encapsulation dot1q 102
load-interval 30
ip vrf forwarding VPN102
ip address 100.102.1.1/24
ipv6 address 102::1/64
!
```

4. Configure service mapping to Flex-Algo.

```
on-demand-nexthop 128
  flex-algo 128
  exit-sr-odn
!
on-demand-nexthop 129
  flex-algo 129
  exit-sr-odn
!
```

5. Configure IS-IS, Flex-Algo SRLG-disjoint, and Flexible Algorithm Definition (FAD).

```
router isis 1
 is-type level-2-only
 capability backup srlg-disjoint path -----> to enable SRLG-disjoint backup path computation for
 default-algo
 capability flex-algo routing
 flex-algo 128
  metric-type igp-metric
  priority 20
  ti-lfa
 backup srlg-disjoint path -----> to enable SRLG-disjoint backup path computation per
 flex-algo
  exclude-srlg 101 -----> this defines FAD to exclude specified SRLG value for
 primary and backup path computation
  exclude-srlg 102
  exclude-srlg 4000000
  exclude-srlg 4294967295
 exit-flex-algo
!
 flex-algo 129
  metric-type te-metric
  priority 20
  ti-lfa
 backup srlg-disjoint path
  exclude-srlg 6
  exclude-srlg 10
  exclude-srlg 181
  exclude-srlg 4
 exit-flex-algo
!
metric-style wide
mpls traffic-eng router-id 1.1.1.1
mpls traffic-eng level-2
dynamic-hostname
 fast-reroute tie-break level-2 proto ipv4 srlg-disjoint index 5 -----> to make SRLG-protecting
 path preferred over node-protecting/link-protecting.
 fast-reroute ti-lfa level-1 proto ipv4
 fast-reroute ti-lfa level-2 proto ipv4
 bfd all-interfaces
 net 49.0001.0000.0000.0022.00
 isis segment-routing global block 16000 19000
 segment-routing mpls
```

6. Configure BGP

```
router bgp 65010
 bgp router-id 1.1.1.1
 bgp auto-policy-soft-reset enable
 neighbor 6.6.6.6 remote-as 65010
```

```

neighbor 6.6.6.6 update-source lo
!
address-family ipv4 unicast
neighbor 6.6.6.6 activate
exit-address-family
!
address-family vpnv4 unicast
neighbor 6.6.6.6 activate
exit-address-family
!
address-family ipv4 vrf VPN101
redistribute connected
neighbor 100.7.1.2 remote-as 200
neighbor 100.7.1.2 activate
exit-address-family
!
address-family ipv4 vrf VPN102
redistribute connected
neighbor 100.102.1.2 remote-as 201
neighbor 100.102.1.2 activate
exit-address-family
!

ip vrf VPN101
rd 65010:100
route-target both 100:100
!
ip vrf VPN102
rd 65010:102
route-target both 102:102
!

```

Similarly, follow the configuration steps for R2, R3, R4, R5, and R6 as shown below:

R2

```

interface lo
ip address 127.0.0.1/8
ip address 2.2.2.2/32 secondary
ipv6 address ::1/128
prefix-sid index 201 no-php
prefix-sid algorithm-num 128 index 2
prefix-sid algorithm-num 129 index 22 explicit-null
ip router isis 1

DUT2#sh run int xe6
!
interface xe6
load-interval 30
ip address 10.10.12.2/24
ip address 10.10.21.2/24 secondary
ip address 10.10.31.2/24 secondary
mtu 9216
label-switching
adjacency-sid isis index 21
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo red
isis admin-group flex-algo white
!
!
DUT2#

```

```
DUT2#sh run int ce2/1
!
interface ce2/1
  load-interval 30
  ip address 10.10.23.2/24
  mtu 9216
  label-switching
  mpls traffic-eng srlg 511
  mpls traffic-eng srlg 512
  adjacency-sid isis index 222
  adjacency-sid ospf absolute 26022
  ip ospf network point-to-point
  isis network point-to-point
  ip router isis 1
  isis te-minimum-delay 5
  isis te-maximum-delay 5
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 5
  isis te-maximum-delay flex-algo 5
  isis admin-group flex-algo red
  isis admin-group flex-algo white
  isis admin-group flex-algo green
  isis srlg flex-algo 5
  isis srlg flex-algo 6
  isis srlg flex-algo 7
  isis srlg flex-algo 5001
  isis srlg flex-algo 5002
  isis srlg flex-algo 5003
!
!
DUT2#
DUT2#sh run int vlan1.100
!
interface vlan1.100
  ip address 10.10.24.2/24
  mtu 9200
  label-switching
  mpls traffic-eng srlg 521
  mpls traffic-eng srlg 15001
  adjacency-sid isis index 24
  isis network point-to-point
  ip router isis 1
  isis te-minimum-delay 5
  isis te-maximum-delay 5
  isis wide-metric 15
  isis te-metric flex-algo ipv4 10
  isis te-minimum-delay flex-algo 5
  isis te-maximum-delay flex-algo 5
  isis admin-group flex-algo white
  isis admin-group flex-algo blue
  isis srlg flex-algo 151
  isis srlg flex-algo 4
  isis srlg flex-algo 1
  isis srlg flex-algo 5
  isis srlg flex-algo 8
!
!
DUT2#sh run int po12
!
interface po12
  load-interval 30
  ip address 10.12.12.2/24
  mtu 9216
  label-switching
  ip ospf network point-to-point
  isis network point-to-point
  ip router isis 1
  isis te-minimum-delay 5
```

```

isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo blue
isis admin-group flex-algo white
!
!
DUT2#

router isis 1
is-type level-2-only
capability backup srlg-disjoint path
capability flex-algo routing
flex-algo 128
  ti-lfa
  backup srlg-disjoint path
exit-flex-algo
!
flex-algo 129
  ti-lfa
  backup srlg-disjoint path
exit-flex-algo
!
metric-style wide
mpls traffic-eng router-id 2.2.2.2
mpls traffic-eng level-2
dynamic-hostname
fast-reroute tie-break level-2 proto ipv4 srlg-disjoint index 5
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0001.0000.0000.0022.00
isis segment-routing global block 16000 19000
segment-routing mpls
!

```

R3

```

interface lo
ip address 127.0.0.1/8
ip address 2.2.2.2/32 secondary
ipv6 address ::1/128
prefix-sid index 201 no-php
prefix-sid algorithm-num 128 index 2
prefix-sid algorithm-num 129 index 22 explicit-null
ip router isis 1

DUT2#sh run int xe6
!
interface xe6
load-interval 30
ip address 10.10.12.2/24
ip address 10.10.21.2/24 secondary
ip address 10.10.31.2/24 secondary
mtu 9216
label-switching
adjacency-sid isis index 21
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo red

```

```
isis admin-group flex-algo white
!
!
DUT2#
DUT2#sh run int ce2/1
!
interface ce2/1
load-interval 30
ip address 10.10.23.2/24
mtu 9216
label-switching
mpls traffic-eng srlg 511
mpls traffic-eng srlg 512
adjacency-sid isis index 222
adjacency-sid ospf absolute 26022
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo red
isis admin-group flex-algo white
isis admin-group flex-algo green
isis srlg flex-algo 5
isis srlg flex-algo 6
isis srlg flex-algo 7
isis srlg flex-algo 5001
isis srlg flex-algo 5002
isis srlg flex-algo 5003
!
!
DUT2#
DUT2#sh run int vlan1.100
!
interface vlan1.100
ip address 10.10.24.2/24
mtu 9200
label-switching
mpls traffic-eng srlg 521
mpls traffic-eng srlg 15001
adjacency-sid isis index 24
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis wide-metric 15
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo white
isis admin-group flex-algo blue
isis srlg flex-algo 151
isis srlg flex-algo 4
isis srlg flex-algo 1
isis srlg flex-algo 5
isis srlg flex-algo 8
!
!
DUT2#sh run int po12
!
interface po12
load-interval 30
ip address 10.12.12.2/24
mtu 9216
label-switching
```

```

ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo blue
isis admin-group flex-algo white
!
!
DUT2#

router isis 1
is-type level-2-only
capability backup srlg-disjoint path
capability flex-algo routing
flex-algo 128
  ti-lfa
  backup srlg-disjoint path
exit-flex-algo
!
flex-algo 129
  ti-lfa
  backup srlg-disjoint path
exit-flex-algo
!
metric-style wide
mpls traffic-eng router-id 2.2.2.2
mpls traffic-eng level-2
dynamic-hostname
fast-reroute tie-break level-2 proto ipv4 srlg-disjoint index 5
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0001.0000.0000.0022.00
isis segment-routing global block 16000 19000
segment-routing mpls
!

```

R4

```

!
interface lo
ip address 127.0.0.1/8
ip address 4.4.4.4/32 secondary
ipv6 address ::1/128
prefix-sid index 401 no-php
prefix-sid algorithm-num 128 index 4
prefix-sid algorithm-num 129 index 44 no-php
!
!
interface ce0
speed 40g
ip address 10.10.45.4/24
mtu 9216
label-switching
admin-group blue
adjacency-sid isis index 45
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10

```

```
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo white
isis admin-group flex-algo green
isis admin-group flex-algo blue
isis srlg flex-algo 15
isis srlg flex-algo 16
isis srlg flex-algo 5001
isis srlg flex-algo 5002
!
!
interface vlan1.100
ip address 10.10.24.4/24
mtu 9200
label-switching
adjacency-sid isis absolute 70042
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo white
isis admin-group flex-algo blue
!
!
interface xe5.101
encapsulation dot1q 14
ip address 10.10.14.4/24
ip address 10.14.15.2/24 secondary
label-switching
admin-group blue
adjacency-sid isis absolute 72101
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo green
!
!

router isis 1
is-type level-2-only
capability backup srlg-disjoint path
capability flex-algo routing
flex-algo 128
ti-lfa
backup srlg-disjoint path
exit-flex-algo
!
flex-algo 129
ti-lfa
backup srlg-disjoint path
exit-flex-algo
!
metric-style wide
mpls traffic-eng router-id 4.4.4.4
mpls traffic-eng level-2
dynamic-hostname
fast-reroute tie-break level-2 proto ipv4 srlg-disjoint index 5
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
```



```
bfd all-interfaces
net 49.0001.0000.0000.0044.00
passive-interface lo
isis segment-routing global block 65000 65800
segment-routing mpls
!
```

R5

```
interface lo
ip address 127.0.0.1/8
ip address 5.5.5.5/32 secondary
ipv6 address ::1/128
prefix-sid index 501 no-php
prefix-sid algorithm-num 128 index 5
prefix-sid algorithm-num 129 index 55 no-php
ip router isis 1
!
!
interface ce2
speed 40g
load-interval 30
ip address 10.10.45.5/24
mtu 9216
label-switching
admin-group blue
adjacency-sid isis index 54
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis admin-group flex-algo green
isis admin-group flex-algo white
isis admin-group flex-algo blue
!
!
!
interface ce3
load-interval 30
ip address 10.10.15.5/24
mtu 9216
label-switching
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 20
isis te-maximum-delay flex-algo 20
isis admin-group flex-algo green
isis admin-group flex-algo blue
!
!
interface po10
load-interval 30
ip address 10.10.35.5/24
mtu 9216
label-switching
admin-group blue
adjacency-sid isis absolute 40124
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
```

```

isis te-maximum-delay flex-algo 5
isis admin-group flex-algo green
isis srlg flex-algo 11
!
!
interface sa50
load-interval 30
ip address 10.10.65.5/24
mtu 9216
label-switching
mpls traffic-eng srlg 559
ip ospf network point-to-point
isis network point-to-point
ip router isis 1
isis te-minimum-delay 5
isis te-maximum-delay 5
isis te-metric flex-algo ipv4 10
isis te-minimum-delay flex-algo 5
isis te-maximum-delay flex-algo 5
isis admin-group flex-algo white
isis admin-group flex-algo green
isis admin-group flex-algo blue
isis srlg flex-algo 12
isis srlg flex-algo 13
isis srlg flex-algo 14
!
!

router isis 1
is-type level-2-only
capability backup srlg-disjoint path
capability flex-algo routing
flex-algo 128
  ti-lfa
  backup srlg-disjoint path
exit-flex-algo
!
flex-algo 129
  ti-lfa
  backup srlg-disjoint path
exit-flex-algo
!
metric-style wide
mpls traffic-eng router-id 5.5.5.5
mpls traffic-eng level-2
dynamic-hostname
fast-reroute tie-break level-2 proto ipv4 srlg-disjoint index 5
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0001.0000.0000.0055.00
passive-interface lo
isis segment-routing global block 16000 19000
segment-routing mpls
!

```

R6

```

!
interface lo
ip address 127.0.0.1/8
ip address 6.6.6.6/32 secondary
ipv6 address ::1/128
prefix-sid index 601 no-php
prefix-sid algorithm-num 128 index 6
prefix-sid algorithm-num 129 index 66 no-php
ip router isis 1

```

```
!  
  
!  
interface xe4  
  ip address 10.10.36.6/24  
  mtu 9216  
  label-switching  
  ip ospf network point-to-point  
  isis network point-to-point  
  ip router isis 1  
  isis te-minimum-delay 5  
  isis te-maximum-delay 5  
  isis te-metric flex-algo ipv4 10  
  isis te-minimum-delay flex-algo 5  
  isis te-maximum-delay flex-algo 5  
  isis admin-group flex-algo green  
  isis admin-group flex-algo white  
!  
!  
interface sa50  
  load-interval 30  
  ip address 10.10.65.6/24  
  mtu 9216  
  label-switching  
  ip ospf network point-to-point  
  isis network point-to-point  
  ip router isis 1  
  isis te-minimum-delay 5  
  isis te-maximum-delay 5  
  isis wide-metric 20  
  isis te-metric flex-algo ipv4 20  
  isis te-minimum-delay flex-algo 5  
  isis te-maximum-delay flex-algo 5  
  isis admin-group flex-algo white  
  isis admin-group flex-algo blue  
  isis admin-group flex-algo green  
  enable-ldp ipv4  
!  
!  
interface xe5.101  
  encapsulation dot1q 101  
  load-interval 30  
  ip vrf forwarding VPN101  
  ip address 100.6.1.1/24  
!  
!  
interface xe5.102  
  encapsulation dot1q 102  
  load-interval 30  
  ip vrf forwarding VPN102  
  ip address 100.102.6.1/24  
!  
  
!  
router isis 1  
  is-type level-2-only  
  capability backup srlg-disjoint path  
  capability flex-algo routing  
  flex-algo 128  
  ti-lfa  
  backup srlg-disjoint path  
  exit-flex-algo  
!  
  flex-algo 129  
  ti-lfa  
  backup srlg-disjoint path  
  exit-flex-algo
```

```

!
metric-style wide
mpls traffic-eng router-id 6.6.6.6
mpls traffic-eng level-2
dynamic-hostname
fast-reroute tie-break level-2 proto ipv4 srlg-disjoint index 5
fast-reroute ti-lfa level-1 proto ipv4
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0001.0000.0000.0066.00
passive-interface lo
isis segment-routing global block 16000 19000
segment-routing entropy-label
segment-routing mpls
!

route-map RM128 permit 10
set extcommunity color 128
!
route-map RM129 permit 10
set extcommunity color 129
!

!
router bgp 65010
  bgp router-id 6.6.6.6
  bgp auto-policy-soft-reset enable
  neighbor 1.1.1.1 remote-as 65010
  neighbor 1.1.1.1 update-source lo
!
  address-family ipv4 unicast
  neighbor 1.1.1.1 activate
  exit-address-family
!
  address-family vpnv4 unicast
  neighbor 1.1.1.1 activate
  exit-address-family
!
  address-family ipv4 vrf VPN101
  redistribute connected route-map RM128
  neighbor 100.6.1.2 remote-as 100
  neighbor 100.6.1.2 activate
  neighbor 100.6.1.2 route-map RM128 in
  exit-address-family
!
  address-family ipv4 vrf VPN102
  redistribute connected route-map RM129
  neighbor 100.102.6.2 remote-as 101
  neighbor 100.102.6.2 activate
  neighbor 100.102.6.2 route-map RM129 in
  exit-address-family
!
!
exit
!
ip vrf VPN101
  rd 6.6.6.6:601
  route-target both 100:100
!
ip vrf VPN102
  rd 6.6.6.6:102
  route-target both 102:102
!

```

Validation

```
DUT1#sh isis flex-algo 128 status winner detail
```

```

ISIS Instance : 1
Router-ID : 1.1.1.1, System-ID : 0000.0000.0001
Algorithm Number : 128
Metric Type : igp-metric
Calculation Type : spf
Priority : 20 (Winner)
Prefix Metric Flag : No
Fwd-Exclude-Any-AG Mask : None
Fwd-Include-Any-AG Mask : None
Fwd-Include-All-AG Mask : None
Rev-Exclude-Any-AG Mask : None
Rev-Include-Any-AG Mask : None
Rev-Include-All-AG Mask : None
Fwd-Exclude-Any-EAG Mask : NULL
Fwd-Include-Any-EAG Mask : NULL
Fwd-Include-All-EAG Mask : NULL
Rev-Exclude-Any-EAG Mask : NULL
Rev-Include-Any-EAG Mask : NULL
Rev-Include-All-EAG Mask : NULL
Exclude SRLG-ID List :
  101 102 4000000 4294967295
Exclude Minimum Bandwidth : 0
Exclude Maximum Delay : 0
Intf-Group Mode Total B/W Calculate : No
Reference Bandwidth : 0
Granularity Bandwidth : 0

```

DUT1#

DUT1#sh isis topology algorithm 128

Tag 1: VRF : default

Flex-Algo : 128

IS-IS paths to level-2 routers

System Id	Metric	Next-Hop	Interface	SNPA
DUT1	--			
DUT3	20	DUT2	po12	80a2.352b.703b
DUT2	10	DUT2	po12	80a2.352b.703b
DUT4	20	DUT4	xe7.101	b86a.97f5.f9cb
DUT5	30	DUT4	xe7.101	b86a.97f5.f9cb
DUT6	30	DUT2	po12	80a2.352b.703b

DUT1#

DUT1#sh mpls forwarding-table 6.6.6.6/32

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	Algo-Num	UpTime			
i>	6.6.6.6/32	69	101	-	-	-	-
	-	128	00:03:07				
			30	0	Yes	16006	po12
10.12.12.2	-	-	100	-			No
	No	65006	xe7.101	No		10.10.14.4	-
i>	6.6.6.6/32	74	116	-	-	-	-
	-	129	00:03:07				
			44	0	Yes	65066	xe7.101
10.10.14.4	-	-	115	-			No
	No	16066	ce1	No		10.10.15.5	-
i>	6.6.6.6/32	12	1222	-	-	-	-
	-	0	01:50:13				
			931	0	Yes	16601	xe10

```

10.10.13.3      -      -
                1221      -
                No      16601      xe7.101      No      10.10.14.4      -      -
DUT1#
DUT1#sh mpls forwarding-table 6.6.6.6/32 algorithm 128
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          Nexthop      FTN-ID      Nhlfe-ID  Tunnel-ID  Pri   Out-Label  Out-
Intf   ELC              UpTime      Algo-Num
i>     6.6.6.6/32      69         101         -         -         -     -         -
        -             128        00:03:55    30         0         Yes    16006      pol2      No
10.12.12.2    -      -
                100      -
                No      65006      xe7.101      No      10.10.14.4      -      -
DUT1#
DUT1# sh mpls ilm-table 6.6.6.6/32
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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Enabled
Code   FEC/VRF/L2CKT  ILM-ID      In-Label      Out-Label      In-Intf      Out-
Intf/VRF Nexthop      pri Algo-Num UpTime      UPStr peers
i>     6.6.6.6/32      94         16006         16006         N/A         pol2
        Yes 128        00:04:15
        No -         -         16006         65006         N/A         xe7.101
i>     6.6.6.6/32      99         16066         65066         N/A         xe7.101
        Yes 129        00:04:15
        No -         -         16066         16066         N/A         ce1
i>     6.6.6.6/32      69         16601         16601         N/A         xe10
        Yes 0         01:51:21
        No -         -         16601         16601         N/A         xe7.101
10.12.12.2
10.10.14.4
10.10.15.5
10.10.13.3
10.10.14.4
DUT1# sh mpls ilm-table 6.6.6.6/32 algo 128
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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Enabled
Code   FEC/VRF/L2CKT  ILM-ID      In-Label      Out-Label      In-Intf      Out-
Intf/VRF Nexthop      pri Algo-Num UpTime      UPStr peers
i>     6.6.6.6/32      94         16006         16006         N/A         pol2
        Yes 128        00:04:54
        No -         -         16006         65006         N/A         xe7.101
10.12.12.2
10.10.14.4
DUT1#
DUT1#show ip isis route tilfa algorithm 128

Tag    : 1   VRF : default
Flex-Algo : 128
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2,
        C - Connected Routes, ia - IS-IS inter area

```

2.2.2.2/32

Route type: L2, FTN-ix :65 ILM-ix :90
SR Incoming Label : 16002
Primary Path Nexthop : 10.12.12.2, po12
SR outgoing Label : 3
PQ node : 4.4.4.4
Backup outgoing Label: 65002
Bypass_trunk id : 2208
Backup out interface : xe7.101
Protection Type : Link Protecting

Trunk : 2209 :2.2.2.2_nh_100012_ALG128 FTN-ix : 76 ref_cnt:2
Number Of outgoing label : 1
3
Nexthop address : 10.12.12.2

3.3.3.3/32

Route type: L2, FTN-ix :66 ILM-ix :91
SR Incoming Label : 16003
Primary Path Nexthop : 10.12.12.2, po12
SR outgoing Label : 16003
PQ node : 4.4.4.4
Backup outgoing Label: 65003
Bypass_trunk id : 2208
Backup out interface : xe7.101
Protection Type : Node Protecting

4.4.4.4/32

Route type: L2, FTN-ix :67 ILM-ix :92
SR Incoming Label : 16004
Primary Path Nexthop : 10.10.14.4, xe7.101
SR outgoing Label : 3
PQ node : 2.2.2.2
Backup outgoing Label: 16004
Bypass_trunk id : 2209
Backup out interface : po12
Protection Type : Link Protecting

Trunk : 2208 :4.4.4.4_nh_328138853_ALG128 FTN-ix : 75 ref_cnt:3
Number Of outgoing label : 1
3
Nexthop address : 10.10.14.4

5.5.5.5/32

Route type: L2, FTN-ix :68 ILM-ix :93
SR Incoming Label : 16005
Primary Path Nexthop : 10.10.14.4, xe7.101
SR outgoing Label : 65005
PQ node : 2.2.2.2
Backup outgoing Label: 16005
Bypass_trunk id : 2209
Backup out interface : po12
Protection Type : Node Protecting

6.6.6.6/32

Route type: L2, FTN-ix :69 ILM-ix :94
SR Incoming Label : 16006
Primary Path Nexthop : 10.12.12.2, po12
SR outgoing Label : 16006
PQ node : 4.4.4.4
Backup outgoing Label: 65006
Bypass_trunk id : 2208
Backup out interface : xe7.101

```

Protection Type      : Node Protecting

DUT1#
DUT1#ping mpls isis-sr ipv4 6.6.6.6/32 algorithm 128 detail
Sending 5 MPLS Echos to 6.6.6.6, 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 10.10.36.6 1.02 ms
! seq_num = 2 10.10.36.6 0.66 ms
! seq_num = 3 10.10.36.6 0.58 ms
! seq_num = 4 10.10.36.6 0.66 ms
! seq_num = 5 10.10.36.6 0.68 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.58/0.80/1.02
DUT1#

```

Commands

The Flexible Algorithm for ISIS with SRLG feature introduces the following configuration command.

capability backup srlg-disjoint path

Use this command to enable TI-LFA SRLG disjoint backup path calculation for default algorithm.

Use the `no` parameter of this command to disable TI-LFA SRLG disjoint backup path calculation for default algorithm.

Command Syntax

```

capability backup srlg-disjoint path
[no] capability backup srlg-disjoint path

```

Parameters

None

Default

None

Command Mode

ISIS Config Mode

Applicability

Introduced in OcNOS version 7.0.0.

Example

```
ocnos(config)#router isis 1  
ocnos(config-router)#flex-algo 128
```

Seamless BFD for SR-TE

This section shows how to configure seamless bfd and how to use isis to advertise local-discriminators. Bidirectional Forwarding Detection (BFD) is a detection protocol designed to provide fast forwarding path failure detection times for all media types, encapsulations, topologies, and routing protocols.

Seamless Bidirectional Forwarding Detection (S-BFD), is a simplified mechanism for using BFD with a large proportion of negotiation aspects eliminated, thus providing benefits such as quick provisioning, as well as improved control and flexibility for network nodes initiating path monitoring. If SBFD session fails, S-BFD does not bring down the SR-TE session. SBFD also provides faster session bring up due to less control packets exchange. S-BFD does not help in bringing up SR-TE session quickly. The BFD state is only maintained at head end thereby reducing overhead.

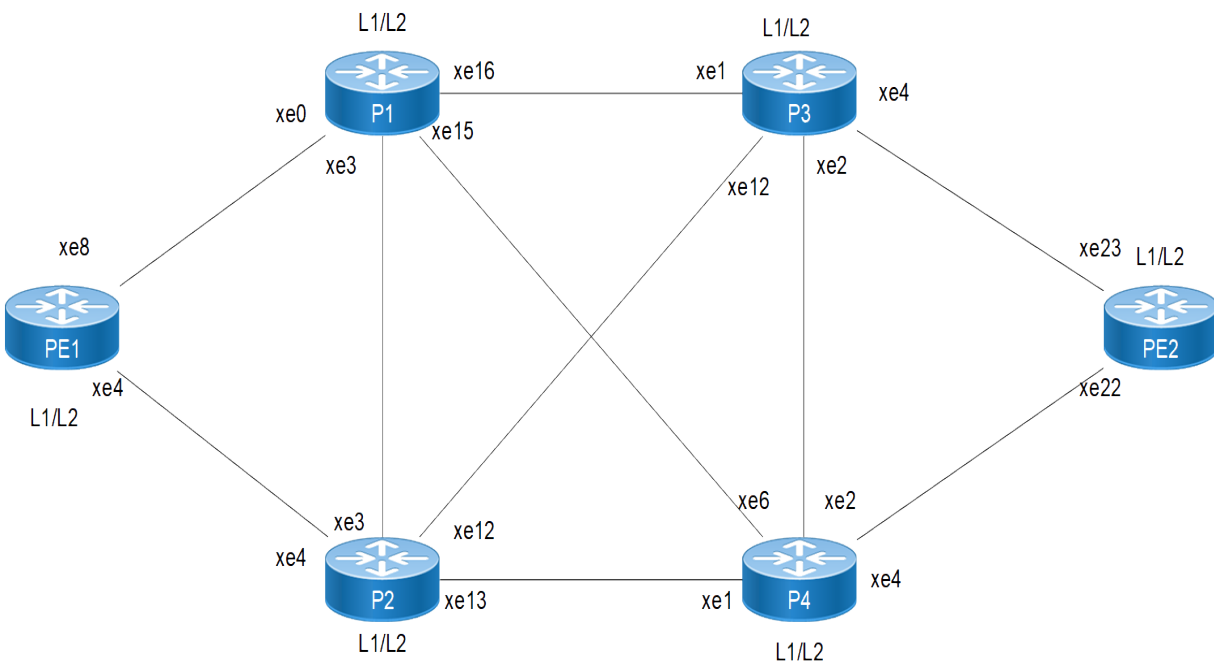
Topology

In Figure :

- "L1" means ISIS routers in Level-1
- "L2" means ISIS routers in Level-2
- "L1/L2" means ISIS routers in both Level-1 and Level-2

Configure a prefix SID on any router directly attached to that network prefix.

Figure 32. BFD for ISIS Segment Routing Topology



Note:

- You must ensure that prefix SIDs are unique globally.

- You can use the pure L1 or L2 routers throughout your SR domain.

Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter the configure mode.
PE1(config)#segment-routing	Enable Segment Routing
PE1(config-sr)#traffic-engineering	Segment routing traffic engineering
PE1(config-sr-te)#segment-list PE3	Segment List configuration
PE1(config-sr-sl)#index 30 segment-type-1 16700	Specify the entry index, Segment-descriptor type: SR-MPLS Label and Label value
PE1(config-sr-sl)#exit-sr-sl	Exit from segment-list configuration mode
PE1(config-sr-te)#policy ocnos	Policy configuration and Policy Name
PE1(config-sr-pol)#color 201 end-point 10.0.1.33	SR Policy color, color value, SR Policy end-point and IPv4 address
PE1(config-sr-pol)#candidate-path 1	SR policy candidate path and Identifier value for candidate path
PE1(config-sr-pol-cp)#preference 200	Candidate Path preference Preference value for candidate path (Default is : 100)
PE1(config-sr-pol-cp)#explicit segment-list PE3	Explicit candidate path, Segment-list for the path and Name of the SID List
PE1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode
PE1(config-sr-pol)# exit-sr-pol	Exit from policy
PE1(config-sr-te)#exit-te	Exit from traffic engineering configuration mode
PE1(config-sr)# commit	Commit the candidate configuration to the running configuration
PE1(config)#s-bfd sr policy ocnos	Seamless-Bidirectional Forwarding Detection, SR type LSP, Policy Name and Input the name of the SR-policy
PE1 (config-sbfd)#min-tx 40 multiplier 40	Set S-BFD Min Tx interval; Default : 10ms and Set S-BFD Detection Multiplier; Default : 5
PE1 (config-sbfd)#commit	Commit the candidate configuration to the running configuration
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ip address 10.0.1.11/32 secondary	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.

PE1(config-if)# prefix-sid index 100 no-php	Configure prefix sid index value with no-php.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#interface xe8	Enter interface mode.
PE1(config-if)#ip address 10.11.1.1/30	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#interface xe4	Enter interface mode.
PE1(config-if)#ip address 10.11.2.1/30	Configure the IP address of the interface.
PE1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#router isis isis1	Set the routing process ID .
PE1(config-router)#metric-style wide	Configure metric style as wide.
PE1(config-router)#is-type level-1-2	Configure is-type with level-1-2.
PE1(config-router)#net 49.0000.0100.0000.1011.00	Configure Network entity title (NET).
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE1(config-router)# dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
PE1(config-router)# isis segment- routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
PE1(config-router)#segment-routing mpls	Enable segment routing under router process.
PE1(config-router)#exit	Exit router mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface lo	Enter interface mode.
P1(config-if)#ip address 10.0.1.1/32 secondary	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)# prefix-sid index 300 no-php	Configure prefix sid index value with no-php.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit the candidate configuration to the running configuration
P1(config)#interface xe0	Enter interface mode.
P1(config-if)#ip address 10.11.1.2/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit the candidate configuration to the running configuration
P1(config)#interface xe3	Enter interface mode.
P1(config-if)#ip address 10.1.2.2/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit the candidate configuration to the running configuration
P1(config)#interface xe15	Enter interface mode.
P1(config-if)#ip address 10.4.1.1/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit the candidate configuration to the running configuration
P1(config)#interface xe16	Enter interface mode.
P1(config-if)#ip address 10.1.1.1/30	Configure the IP address of the interface.
P1(config-if)#ip router isis isis1	Make the interface part of the router isis isis1

	instance.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#exit	Exit interface mode.
P1(config)#commit	Commit the candidate configuration to the running configuration
P1(config)#router isis isis1	Set the routing process ID .
P1(config-router)#metric-style wide	Configure metric style as wide.
P1(config-router)#is-type level-1-2	Configure is-type with level-1-2.
P1(config-router)#net 49.0000.0100.0000.1001.00	Configure Network entity title (NET).
P1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P1(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
P1(config-router)# isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
P1(config-router)#segment-routing mpls	Enable segment routing under router process.
P1(config-router)#exit	Exit router mode.
P1(config)#commit	Commit the candidate configuration to the running configuration

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#s-bfd discriminator 10.0.1.2	Discriminator value for reflector
P2(config)#commit	Commit the candidate configuration to the running configuration
P2(config)#interface lo	Enter interface mode.
P2(config-if)#ip address 10.0.1.2/32 secondary	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)# prefix-sid index 400 no-php	Configure prefix sid index value with no php.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit the candidate configuration to the running configuration
P2(config)#interface xe3	Enter interface mode.
P2(config-if)# ip address 10.1.2.1/30	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1

	instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#interface xe4	Enter interface mode.
P2(config-if)#ip address 10.11.2.2/30	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit the candidate configuration to the running configuration
P2(config)#interface xe12	Enter interface mode.
P2(config-if)#ip address 10.2.1.1/30	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit the candidate configuration to the running configuration
P2(config)#interface xe13	Enter interface mode.
P2(config-if)#ip address 10.4.2.2/30	Configure the IP address of the interface.
P2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#exit	Exit interface mode.
P2(config)#commit	Commit the candidate configuration to the running configuration
P2(config)#router isis isis1	Set the routing process ID .
P2(config-router)#metric-style wide	Configure metric style as wide.
P2(config-router)#is-type level-1-2	Configure is-type with level-1-2.
P2(config-router)#net 49.0000.0100.0000.1002.00	Configure Network entity title (NET).
P2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2 as well.
P2 (config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
P2(config-router)#isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.

P2(config-router)#segment-routing mpls	Enable segment routing under router process.
P2(config-router)#exit	Exit router mode.
P2(config)#commit	Commit the candidate configuration to the running configuration

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#s-bfd discriminator 10.0.1.3	Discriminator value for reflector
P3(config)#commit	Commit the candidate configuration to the running configuration
P3(config)#interface lo	Enter interface mode.
P3(config-if)#ip address 10.0.1.3/32 secondary	Configure the IP address of the interface.
P3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P3(config-if)#prefix-sid index 500 no-php	Configure prefix sid index value with no php.
P3(config-if)#exit	Exit interface mode.
P3(config)#commit	Commit the candidate configuration to the running configuration
P3(config)#interface xe1	Enter interface mode.
P3(config-if)#ip address 10.1.1.2/30	Configure the IP address of the interface.
P3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#commit	Commit the candidate configuration to the running configuration
P3(config)#interface xe2	Enter interface mode.
P3(config-if)#ip address 10.3.2.1/30	Configure the IP address of the interface.
P3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#commit	Commit the candidate configuration to the running configuration
P3(config)#interface xe4	Enter interface mode.

P3(config-if)#ip address 10.33.1.2/30	Configure the IP address of the interface.
P3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#commit	Commit the candidate configuration to the running configuration
P3(config)#interface xel2	Enter interface mode.
P3(config-if)#ip address 10.2.1.2/30	Configure the IP address of the interface.
P3(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#exit	Exit interface mode.
P3(config)#commit	Commit the candidate configuration to the running configuration
P3(config)#router isis isis1	Set the routing process ID .
P3(config-router)#metric-style wide	Configure metric style as wide.
P3(config-router)#is-type level-1-2	Configure is-type with level-1-2.
P3(config-router)#net 49.0000.0100.0000.1003.00	Configure Network entity title (NET).
P3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P3(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2 as well.
P3(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
P3(config-router)#isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
P3(config-router)#segment-routing mpls	Enable segment routing under router process.
P3(config-router)#exit	Exit router mode.
P3(config)#commit	Commit the candidate configuration to the running configuration

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#s-bfd discriminator 10.0.1.4	Discriminator value for reflector
P4(config)#commit	Commit the candidate configuration to the running configuration

P4(config)#interface lo	Enter interface mode.
P4(config-if)#ip address 10.0.1.4/32 secondary	Configure the IP address of the interface.
P4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P4(config-if)# prefix-sid index 600 no-php	Configure prefix sid index value with no php.
P4(config-if)#exit	Exit interface mode.
P4(config)#commit	Commit the candidate configuration to the running configuration
P4(config)#interface xe1	Enter interface mode.
P4(config-if)#ip address 10.4.2.1/30	Configure the IP address of the interface.
P4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#interface xe2	Enter interface mode.
P4(config-if)#ip address 10.3.2.2/30	Configure the IP address of the interface.
P4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#commit	Commit the candidate configuration to the running configuration
P4(config)#interface xe4	Enter interface mode.
P4(config-if)#ip address 10.44.5.1/30	Configure the IP address of the interface.
P4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#commit	Commit the candidate configuration to the running configuration
P4(config)#interface xe6	Enter interface mode.
P4(config-if)#ip address 10.4.1.2/30	Configure the IP address of the interface.
P4(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
P4(config-if)#label-switching	Enable label switching.
P4(config-if)#exit	Exit interface mode.
P4(config)#commit	Commit the candidate configuration to the running configuration

P4(config)#router isis isis1	Set the routing process ID .
P4(config-router)#metric-style wide	Configure metric style as wide.
P4(config-router)#is-type level-1-2	Configure is-type with level-1-2.
P4(config-router)#net 49.0000.0100.0000.1004.00	Configure Network entity title (NET).
P4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P4(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2 as well.
P4(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process.
P4(config-router)#isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
P4(config-router)#segment-routing mpls	Enable segment routing under router process.
P4(config-router)#exit	Exit router mode.
P4(config)#commit	Commit the candidate configuration to the running configuration

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#s-bfd discriminator 10.0.1.33	Discriminator value for reflector
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)#ip address 10.0.1.33/32 secondary	Configure the IP address of the interface.
PE2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE2(config-if)# prefix-sid index 700 no-php	Configure prefix sid index value with no-php.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#interface xe22	Enter interface mode.
PE2(config-if)#ip address 10.44.5.2/30	Configure the IP address of the interface.
PE2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration

	configuration
PE2(config)#interface xe23	Enter interface mode.
PE2(config-if)#ip address 10.33.1.1/30	Configure the IP address of the interface.
PE2(config-if)#ip router isis isis1	Make the interface part of the router isis isis1 instance.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#router isis isis1	Set the routing process ID .
PE2(config-router)#metric-style wide	Configure metric style as wide.
PE2(config-router)#is-type level-1-2	Configure is-type with level-1-2.
PE2(config-router)#net 49.0000.0100.0000.1033.00	Configure Network entity title (NET).
PE2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level- 2 as well.
PE2(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS isis1 process
PE2(config-router)# isis segment-routing global block 16000 23999	Enable SRGB under ISIS isis1 process.
PE2(config-router)#segment-routing mpls	Enable segment routing under router process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration



Note: By default, PHP is enabled, to see all the labels in MPLS forwarding and ILM table we have enabled with non- php option.

Validation

Validation 1

Verify BFD Session

```
PE2-7048#show bfd session
```

```
BFD process for VRF: (DEFAULT VRF)
```

```
=====
Sess-Idx  Remote-Disc  Lower-Layer  Sess-Type  Sess-State  UP-Time  Interface  Down-
Reason  Remote-Addr
1281      45.45.45.45  MPLS LSP     Single-
Hop Up      00:01:15    po1.10      NA          45.45.45.45/32
```

Number of Sessions: 1

PE2-7048#show segment-routing policy detail

```

Policy-Name: 1      Color 1      End-point 45.45.45.45      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:01:13
State Transition Count: 1
CSPF Retry Limit: 100      CSPF Retry Interval: 10
S-BFD is enabled.
Binding SID :
BSID: 25600
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 300      Path Type: Explicit      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :16042
Segment1[LABEL]: Label :16045
Out-if: po1.10      Out-label-stack: 3/16045
Backup ftn_ix: 6      (calculated based on s-bfd)
Attributes:
Configured:
Explicit segment-list Name: 48-42
Last Recorded Error: Next-hop resolution failed for SID-LIST, 00:02:15 ago

CP ID: 2, S-BFD backup
Preference: 100      Path Type: Explicit      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :16043
Segment1[LABEL]: Label :16045
Out-if: xe0      Out-label-stack: 3/16045
Attributes:
Configured:
Explicit segment-list Name: 48-43
Last Recorded Error: Next-hop resolution failed for SID-LIST, 00:02:15 ago

```

Verify ISIS neighbor adjacency between routers.

PE1#show clns neighbors

```

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag isis1: VRF : default
System Id      Interface      SNPA      State      Holdtime      Type Protocol
P2              xe4              e8c5.7a79.5722      Up      20      L1      IS-IS
                Up      20      L2      IS-IS
P1              xe8              9819.2ca4.1c04      Up      20      L1      IS-IS
                Up      20      L2      IS-IS

```

P1#sh clns neighbors

```

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8
Tag isis1: VRF : default
System Id      Interface      SNPA      State      Holdtime      Type Protocol
PE1              xe0              e8c5.7a90.cc76      Up      8      L1      IS-IS
                Up      8      L2      IS-IS
P2              xe3              e8c5.7a79.5721      Up      9      L1      IS-IS

```

```

P4          xe15          903c.b32e.0349    Up    9      L2    IS-IS
P4          xe15          903c.b32e.0349    Up    28     L1    IS-IS
P3          xe16          e8c5.7a8b.a81f    Up    28     L2    IS-IS
P3          xe16          e8c5.7a8b.a81f    Up    9      L1    IS-IS
P3          xe16          e8c5.7a8b.a81f    Up    9      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 isis1: VRF : default
System Id   Interface   SNPA          State Holdtime Type Protocol
P1          xe3          9819.2ca4.1c07 Up    22     L1    IS-IS
P1          xe3          9819.2ca4.1c07 Up    22     L2    IS-IS
PE1         xe4          e8c5.7a90.cc72 Up    6      L1    IS-IS
PE1         xe4          e8c5.7a90.cc72 Up    6      L2    IS-IS
P3          xe12         e8c5.7a8b.a82a Up    6      L1    IS-IS
P3          xe12         e8c5.7a8b.a82a Up    6      L2    IS-IS
P4          xe13         903c.b32e.0344 Up    22     L1    IS-IS
P4          xe13         903c.b32e.0344 Up    22     L2    IS-IS
P2#

P3#sh clns neighbors

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8
Tag isis1: VRF : default
System Id   Interface   SNPA          State Holdtime Type Protocol
P1          xe1          9819.2ca4.1c14 Up    28     L1    IS-IS
P1          xe1          9819.2ca4.1c14 Up    28     L2    IS-IS
P4          xe2          903c.b32e.0345 Up    28     L1    IS-IS
P4          xe2          903c.b32e.0345 Up    28     L2    IS-IS
PE2         xe4          80a2.35ec.d679 Up    27     L1    IS-IS
PE2         xe4          80a2.35ec.d679 Up    27     L2    IS-IS
P2          xe12         e8c5.7a79.572a Up    27     L1    IS-IS
P2          xe12         e8c5.7a79.572a Up    27     L2    IS-IS
P3#

P4#sh clns neighbors

Total number of L1 adjacencies: 4
Total number of L2 adjacencies: 4
Total number of adjacencies: 8
Tag isis1: VRF : default
System Id   Interface   SNPA          State Holdtime Type Protocol
P2          xe1          e8c5.7a79.572b Up    6      L1    IS-IS
P2          xe1          e8c5.7a79.572b Up    6      L2    IS-IS
P3          xe2          e8c5.7a8b.a820 Up    6      L1    IS-IS
P3          xe2          e8c5.7a8b.a820 Up    6      L2    IS-IS
PE2         xe4          80a2.35ec.d678 Up    25     L1    IS-IS
PE2         xe4          80a2.35ec.d678 Up    25     L2    IS-IS
P1          xe6          9819.2ca4.1c13 Up    6      L1    IS-IS
P1          xe6          9819.2ca4.1c13 Up    6      L2    IS-IS
P4#

PE2#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 2
Total number of adjacencies: 4
Tag isis1: VRF : default
System Id   Interface   SNPA          State Holdtime Type Protocol
P4          xe22         903c.b32e.0347 Up    5      L1    IS-IS
P4          xe22         903c.b32e.0347 Up    5      L2    IS-IS
P3          xe23         e8c5.7a8b.a822 Up    5      L1    IS-IS
P3          xe23         e8c5.7a8b.a822 Up    5      L2    IS-IS
PE2#

```

Validation 2

The command output below displays the details of routers configured with segment routing.

```

PE1#show isis segment-routing capability

Tag isis1 Segment-Routing:
-----
Advertisement Router Capability :10.0.1.1
Algorithm0                    :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----
Advertisement Router Capability :10.0.1.2
Algorithm0                    :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----
Advertisement Router Capability :10.0.1.3
Algorithm0                    :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----
Advertisement Router Capability :10.0.1.4
Algorithm0                    :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----
Advertisement Router Capability :10.0.1.11
Algorithm0                    :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----
Advertisement Router Capability :10.0.1.33
Algorithm0                    :0
SRMS Preference               :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 23999
-----
PE1#
PE1#
PE1#
PE1#sh isis segment-routing state

Tag isis1 Segment-Routing:
SR State: SR_ENABLED
SRGB Start: 16000, SRGB Range: 8000
Operational state: enabled
PE1#

```

Validation 3

Verify that segment routing information is present in ISIS database.

```

PE1#show isis database verbose
Tag isis1: VRF : default
IS-IS Level-1 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
P1.00-00       0x00000004   0x8CE8        825           0/0/0
  Area Address: 49.0000
  NLPID:        0xCC
  Hostname:     P1
  IP Address:   10.0.1.1
  Router ID:    10.0.1.1
  Router Cap:   10.0.1.1
    SRGB Range: 8000    SRGB Base SID: 16000  I:1 V:0
    SR-Algorithm:
      Algorithm: 0
    SBFD Discriminator: 10.0.1.1
  Metric: 10          IS-Extended P2.05
  IPv4 Interface Address: 10.1.2.2
  Neighbor IP Address: 10.1.2.1
  Maximum Link Bandwidth: 25g
  Reservable Bandwidth: 25g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 25g
    Unreserved Bandwidth at priority 1: 25g
    Unreserved Bandwidth at priority 2: 25g
    Unreserved Bandwidth at priority 3: 25g
    Unreserved Bandwidth at priority 4: 25g
    Unreserved Bandwidth at priority 5: 25g
    Unreserved Bandwidth at priority 6: 25g
    Unreserved Bandwidth at priority 7: 25g
  TE-Default Metric: 10
  System-ID: 0100.0000.1002 LAN Adjacency SID: 24321  F:0 B:0 V:1 L:1 S:0 P:0
  Metric: 10          IS-Extended P3.02
  IPv4 Interface Address: 10.1.1.1
  Neighbor IP Address: 10.1.1.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0100.0000.1003 LAN Adjacency SID: 24323  F:0 B:0 V:1 L:1 S:0 P:0
  Metric: 10          IS-Extended P1.04
  IPv4 Interface Address: 10.4.1.1
  Neighbor IP Address: 10.4.1.1
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g

```



```

TE-Default Metric: 10
System-ID: 0100.0000.1004 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE1.03
IPv4 Interface Address: 10.11.1.2
Neighbor IP Address: 10.11.1.1
Maximum Link Bandwidth: 25g
Reservable Bandwidth: 25g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 25g
  Unreserved Bandwidth at priority 1: 25g
  Unreserved Bandwidth at priority 2: 25g
  Unreserved Bandwidth at priority 3: 25g
  Unreserved Bandwidth at priority 4: 25g
  Unreserved Bandwidth at priority 5: 25g
  Unreserved Bandwidth at priority 6: 25g
  Unreserved Bandwidth at priority 7: 25g
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.1/32
Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.11.1.0/30
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.4.1.0/30
Metric: 10 IP-Extended 10.1.1.0/30
P1.04-00 0x00000001 0xCBC6 796 0/0/0
Metric: 0 IS-Extended P1.00
Metric: 0 IS-Extended P4.00
P2.00-00 0x00000004 0x2EA9 824 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P2
IP Address: 10.0.1.2
Router ID: 10.0.1.2
Router Cap: 10.0.1.2
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
  Algorithm: 0
SBFD Discriminator: 10.0.1.2
Metric: 10 IS-Extended P2.04
IPv4 Interface Address: 10.4.2.2
Neighbor IP Address: 10.4.2.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1004 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P3.06
IPv4 Interface Address: 10.2.1.1
Neighbor IP Address: 10.2.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g

```

```

TE-Default Metric: 10
System-ID: 0100.0000.1003 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.2
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P2.05
IPv4 Interface Address: 10.1.2.1
Neighbor IP Address: 10.1.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.2/32
Prefix-SID: index 400 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.11.2.0/30
Metric: 10 IP-Extended 10.2.1.0/30
Metric: 10 IP-Extended 10.4.2.0/30
P2.04-00 0x00000001 0xCCC3 796 0/0/0
Metric: 0 IS-Extended P2.00
Metric: 0 IS-Extended P4.00
P2.05-00 0x00000001 0x8909 796 0/0/0
Metric: 0 IS-Extended P2.00
Metric: 0 IS-Extended P1.00
P3.00-00 0x00000004 0x4651 824 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P3
IP Address: 10.0.1.3
Router ID: 10.0.1.3
Router Cap: 10.0.1.3
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
  Algorithm: 0
SBFD Discriminator: 10.0.1.3
Metric: 10 IS-Extended P3.04
IPv4 Interface Address: 10.33.1.2
Neighbor IP Address: 10.33.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g

```

```

    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1033 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P3.06
IPv4 Interface Address: 10.2.1.2
Neighbor IP Address: 10.2.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P3.02
IPv4 Interface Address: 10.1.1.2
Neighbor IP Address: 10.1.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P3.03
IPv4 Interface Address: 10.3.2.1
Neighbor IP Address: 10.3.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1004 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.3/32
Prefix-SID: index 500 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.1.0/30
Metric: 10 IP-Extended 10.3.2.0/30
Metric: 10 IP-Extended 10.33.1.0/30
Metric: 10 IP-Extended 10.33.44.0/30
Metric: 10 IP-Extended 10.2.1.0/30
P3.02-00 0x00000001 0x9FF3 797 0/0/0
Metric: 0 IS-Extended P3.00
Metric: 0 IS-Extended P1.00
P3.03-00 0x00000001 0xD4BA 796 0/0/0
Metric: 0 IS-Extended P3.00
Metric: 0 IS-Extended P4.00
P3.04-00 0x00000001 0x7DE1 797 0/0/0
Metric: 0 IS-Extended P3.00

```

```
Metric: 0          IS-Extended PE2.00
P3.06-00          0x00000001  0x97F6      796          0/0/0
Metric: 0          IS-Extended P3.00
Metric: 0          IS-Extended P2.00
P4.00-00          0x00000004  0x1369      825          0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P4
IP Address: 10.0.1.4
Router ID: 10.0.1.4
Router Cap: 10.0.1.4
SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
SR-Algorithm:
  Algorithm: 0
SBFD Discriminator: 10.0.1.4
Metric: 10         IS-Extended P2.04
IPv4 Interface Address: 10.4.2.1
Neighbor IP Address: 10.4.2.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 24320   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IS-Extended P1.04
IPv4 Interface Address: 10.4.1.2
Neighbor IP Address: 10.4.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24323   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IS-Extended P3.03
IPv4 Interface Address: 10.3.2.2
Neighbor IP Address: 10.3.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1003 LAN Adjacency SID: 24321   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IS-Extended P4.03
IPv4 Interface Address: 10.44.5.1
Neighbor IP Address: 10.44.5.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
```

```

Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1033 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.4/32
Prefix-SID: index 600 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.4.2.0/30
Metric: 10 IP-Extended 10.3.2.0/30
Metric: 10 IP-Extended 10.44.5.0/30
Metric: 10 IP-Extended 10.4.1.0/30
P4.03-00 0x00000001 0x85D8 796 0/0/0
Metric: 0 IS-Extended P4.00
Metric: 0 IS-Extended PE2.00
PE1.00-00 * 0x00000004 0x119E 825 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE1
IP Address: 10.0.1.11
Router ID: 10.0.1.11
Router Cap: 10.0.1.11
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
  Algorithm: 0
Metric: 10 IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.1
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 26240 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE1.03
IPv4 Interface Address: 10.11.1.1
Neighbor IP Address: 10.11.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 26241 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.11.2.0/30
Metric: 10 IP-Extended 10.11.22.0/30
Metric: 10 IP-Extended 10.11.1.0/30
PE1.03-00 * 0x00000001 0xA6CF 797 0/0/0

```

```

Metric: 0          IS-Extended PE1.00
Metric: 0          IS-Extended P1.00
PE1.04-00          * 0x00000001 0xB3C0          797          0/0/0
Metric: 0          IS-Extended PE1.00
Metric: 0          IS-Extended P2.00
PE2.00-00          0x00000005 0x076F          930          0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: PE2
IP Address: 10.0.1.33
Router ID: 10.0.1.33
Router Cap: 10.0.1.33
SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
SR-Algorithm:
Algorithm: 0
SBFD Discriminator: 10.0.1.33
Metric: 10         IS-Extended P4.03
IPv4 Interface Address: 10.44.5.2
Neighbor IP Address: 10.44.5.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 10g
Unreserved Bandwidth at priority 1: 10g
Unreserved Bandwidth at priority 2: 10g
Unreserved Bandwidth at priority 3: 10g
Unreserved Bandwidth at priority 4: 10g
Unreserved Bandwidth at priority 5: 10g
Unreserved Bandwidth at priority 6: 10g
Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1004 LAN Adjacency SID: 25600   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IS-Extended P3.04
IPv4 Interface Address: 10.33.1.1
Neighbor IP Address: 10.33.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 10g
Unreserved Bandwidth at priority 1: 10g
Unreserved Bandwidth at priority 2: 10g
Unreserved Bandwidth at priority 3: 10g
Unreserved Bandwidth at priority 4: 10g
Unreserved Bandwidth at priority 5: 10g
Unreserved Bandwidth at priority 6: 10g
Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1003 LAN Adjacency SID: 25601   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10         IP-Extended 10.0.1.33/32
Prefix-SID: index 700 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10         IP-Extended 10.44.5.0/30
Metric: 10         IP-Extended 10.33.1.0/30

IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
P1.00-00       0x00000007   0x8175        931           0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P1
IP Address: 10.0.1.1
Router ID: 10.0.1.1
Router Cap: 10.0.1.1
SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
SR-Algorithm:
Algorithm: 0
SBFD Discriminator: 10.0.1.1
Metric: 10         IS-Extended P2.05
IPv4 Interface Address: 10.1.2.2

```

```
Neighbor IP Address: 10.1.2.1
Maximum Link Bandwidth: 25g
Reservable Bandwidth: 25g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 25g
  Unreserved Bandwidth at priority 1: 25g
  Unreserved Bandwidth at priority 2: 25g
  Unreserved Bandwidth at priority 3: 25g
  Unreserved Bandwidth at priority 4: 25g
  Unreserved Bandwidth at priority 5: 25g
  Unreserved Bandwidth at priority 6: 25g
  Unreserved Bandwidth at priority 7: 25g
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P3.02
IPv4 Interface Address: 10.1.1.1
Neighbor IP Address: 10.1.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1003 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P1.04
IPv4 Interface Address: 10.4.1.1
Neighbor IP Address: 10.4.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1004 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE1.03
IPv4 Interface Address: 10.11.1.2
Neighbor IP Address: 10.11.1.1
Maximum Link Bandwidth: 25g
Reservable Bandwidth: 25g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 25g
  Unreserved Bandwidth at priority 1: 25g
  Unreserved Bandwidth at priority 2: 25g
  Unreserved Bandwidth at priority 3: 25g
  Unreserved Bandwidth at priority 4: 25g
  Unreserved Bandwidth at priority 5: 25g
  Unreserved Bandwidth at priority 6: 25g
  Unreserved Bandwidth at priority 7: 25g
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.1/32
Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.11.1.0/30
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.4.1.0/30
Metric: 10 IP-Extended 10.1.1.0/30
```

```

Metric: 20 IP-Extended 10.0.1.2/32
Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.3/32
Prefix-SID: index 500 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.4/32
Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30 IP-Extended 10.0.1.33/32
Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20 IP-Extended 10.2.1.0/30
Metric: 20 IP-Extended 10.3.2.0/30
Metric: 20 IP-Extended 10.4.2.0/30
Metric: 20 IP-Extended 10.11.2.0/30
Metric: 20 IP-Extended 10.11.22.0/30
Metric: 20 IP-Extended 10.33.1.0/30
Metric: 20 IP-Extended 10.33.44.0/30
Metric: 20 IP-Extended 10.44.5.0/30
P1.04-00 0x00000001 0xCBC6 796 0/0/0
Metric: 0 IS-Extended P1.00
Metric: 0 IS-Extended P4.00
P2.00-00 0x00000008 0x7B45 931 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P2
IP Address: 10.0.1.2
Router ID: 10.0.1.2
Router Cap: 10.0.1.2
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
Algorithm: 0
SBFD Discriminator: 10.0.1.2
Metric: 10 IS-Extended P3.06
IPv4 Interface Address: 10.2.1.1
Neighbor IP Address: 10.2.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 10g
Unreserved Bandwidth at priority 1: 10g
Unreserved Bandwidth at priority 2: 10g
Unreserved Bandwidth at priority 3: 10g
Unreserved Bandwidth at priority 4: 10g
Unreserved Bandwidth at priority 5: 10g
Unreserved Bandwidth at priority 6: 10g
Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1003 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P2.04
IPv4 Interface Address: 10.4.2.2
Neighbor IP Address: 10.4.2.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 10g
Unreserved Bandwidth at priority 1: 10g
Unreserved Bandwidth at priority 2: 10g
Unreserved Bandwidth at priority 3: 10g
Unreserved Bandwidth at priority 4: 10g
Unreserved Bandwidth at priority 5: 10g
Unreserved Bandwidth at priority 6: 10g
Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1004 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P2.05
IPv4 Interface Address: 10.1.2.1
Neighbor IP Address: 10.1.2.1
Maximum Link Bandwidth: 10g

```



```

Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.2
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1011 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.2/32
Prefix-SID: index 400 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.1.2.0/30
Metric: 10 IP-Extended 10.11.2.0/30
Metric: 10 IP-Extended 10.2.1.0/30
Metric: 10 IP-Extended 10.4.2.0/30
Metric: 20 IP-Extended 10.0.1.1/32
Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.3/32
Prefix-SID: index 500 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.4/32
Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30 IP-Extended 10.0.1.33/32
Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20 IP-Extended 10.1.1.0/30
Metric: 20 IP-Extended 10.3.2.0/30
Metric: 20 IP-Extended 10.4.1.0/30
Metric: 20 IP-Extended 10.11.1.0/30
Metric: 20 IP-Extended 10.11.22.0/30
Metric: 20 IP-Extended 10.33.1.0/30
Metric: 20 IP-Extended 10.33.44.0/30
Metric: 20 IP-Extended 10.44.5.0/30
P2.04-00 0x00000001 0xCCC3 796 0/0/0
Metric: 0 IS-Extended P2.00
Metric: 0 IS-Extended P4.00
P2.05-00 0x00000001 0x8909 796 0/0/0
Metric: 0 IS-Extended P2.00
Metric: 0 IS-Extended P1.00
P3.00-00 0x00000008 0xC9B7 931 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P3
IP Address: 10.0.1.3
Router ID: 10.0.1.3
Router Cap: 10.0.1.3
SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
SR-Algorithm:
Algorithm: 0

```

```
SBFD Discriminator: 10.0.1.3
Metric: 10          IS-Extended P3.04
IPv4 Interface Address: 10.33.1.2
Neighbor IP Address: 10.33.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1033 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended P3.06
IPv4 Interface Address: 10.2.1.2
Neighbor IP Address: 10.2.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended P3.02
IPv4 Interface Address: 10.1.1.2
Neighbor IP Address: 10.1.1.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended P3.03
IPv4 Interface Address: 10.3.2.1
Neighbor IP Address: 10.3.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1004 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 10.0.1.3/32
Prefix-SID: index 500 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 10.1.1.0/30
```

```

Metric: 10      IP-Extended 10.3.2.0/30
Metric: 10      IP-Extended 10.33.1.0/30
Metric: 10      IP-Extended 10.33.44.0/30
Metric: 10      IP-Extended 10.2.1.0/30
Metric: 20      IP-Extended 10.0.1.33/32
  Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20      IP-Extended 10.44.5.0/30
Metric: 20      IP-Extended 10.0.1.1/32
  Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20      IP-Extended 10.0.1.2/32
  Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20      IP-Extended 10.0.1.4/32
  Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30      IP-Extended 10.0.1.11/32
  Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20      IP-Extended 10.1.2.0/30
Metric: 20      IP-Extended 10.4.1.0/30
Metric: 20      IP-Extended 10.4.2.0/30
Metric: 20      IP-Extended 10.11.1.0/30
Metric: 20      IP-Extended 10.11.2.0/30
Metric: 30      IP-Extended 10.11.22.0/30
P3.02-00      0x00000001 0x9FF3      796      0/0/0
  Metric: 0      IS-Extended P3.00
  Metric: 0      IS-Extended P1.00
P3.03-00      0x00000001 0xD4BA      796      0/0/0
  Metric: 0      IS-Extended P3.00
  Metric: 0      IS-Extended P4.00
P3.04-00      0x00000001 0x7DE1      796      0/0/0
  Metric: 0      IS-Extended P3.00
  Metric: 0      IS-Extended PE2.00
P3.06-00      0x00000001 0x97F6      796      0/0/0
  Metric: 0      IS-Extended P3.00
  Metric: 0      IS-Extended P2.00
P4.00-00      0x00000007 0xB896      931      0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: P4
IP Address: 10.0.1.4
Router ID: 10.0.1.4
Router Cap: 10.0.1.4
  SRGB Range: 8000  SRGB Base SID: 16000  I:1 V:0
  SR-Algorithm:
    Algorithm: 0
  SBFD Discriminator: 10.0.1.4
Metric: 10      IS-Extended P2.04
IPv4 Interface Address: 10.4.2.1
Neighbor IP Address: 10.4.2.2
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 24320  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended P1.04
IPv4 Interface Address: 10.4.1.2
Neighbor IP Address: 10.4.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g

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```

    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 24323 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P3.03
IPv4 Interface Address: 10.3.2.2
Neighbor IP Address: 10.3.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1003 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IS-Extended P4.03
IPv4 Interface Address: 10.44.5.1
Neighbor IP Address: 10.44.5.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1033 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.0.1.4/32
Prefix-SID: index 600 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 10.4.2.0/30
Metric: 10 IP-Extended 10.3.2.0/30
Metric: 10 IP-Extended 10.44.5.0/30
Metric: 10 IP-Extended 10.4.1.0/30
Metric: 20 IP-Extended 10.0.1.1/32
Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.2/32
Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.3/32
Prefix-SID: index 500 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30 IP-Extended 10.0.1.11/32
Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 10.0.1.33/32
Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20 IP-Extended 10.1.1.0/30
Metric: 20 IP-Extended 10.1.2.0/30
Metric: 20 IP-Extended 10.2.1.0/30
Metric: 20 IP-Extended 10.11.1.0/30
Metric: 20 IP-Extended 10.11.2.0/30
Metric: 30 IP-Extended 10.11.22.0/30
Metric: 20 IP-Extended 10.33.1.0/30
Metric: 20 IP-Extended 10.33.44.0/30
P4.03-00 0x00000001 0x85D8 796 0/0/0
Metric: 0 IS-Extended P4.00
Metric: 0 IS-Extended PE2.00
PE1.00-00 * 0x00000007 0xCE3C 932 0/0/0

```

```

Area Address: 49.0000
NLPID:      0xCC
Hostname:    PE1
IP Address:  10.0.1.11
Router ID:   10.0.1.11
Router Cap:  10.0.1.11
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric:      10      IS-Extended PE1.04
IPv4 Interface Address: 10.11.2.1
Neighbor IP Address: 10.11.2.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1002 LAN Adjacency SID: 26240   F:0 B:0 V:1 L:1 S:0 P:0
Metric:      10      IS-Extended PE1.03
IPv4 Interface Address: 10.11.1.1
Neighbor IP Address: 10.11.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0100.0000.1001 LAN Adjacency SID: 26241   F:0 B:0 V:1 L:1 S:0 P:0
Metric:      10      IP-Extended 10.0.1.11/32
  Prefix-SID: index 100 R:0 N:1 P:1 E:0 V:0 L:0
Metric:      10      IP-Extended 10.11.2.0/30
Metric:      10      IP-Extended 10.11.22.0/30
Metric:      10      IP-Extended 10.11.1.0/30
Metric:      20      IP-Extended 10.0.1.1/32
  Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric:      20      IP-Extended 10.0.1.2/32
  Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
Metric:      30      IP-Extended 10.0.1.3/32
  Prefix-SID: index 500 R:1 N:0 P:1 E:0 V:0 L:0
Metric:      30      IP-Extended 10.0.1.4/32
  Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
Metric:      40      IP-Extended 10.0.1.33/32
  Prefix-SID: index 700 R:1 N:0 P:0 E:0 V:0 L:0
Metric:      20      IP-Extended 10.1.1.0/30
Metric:      20      IP-Extended 10.1.2.0/30
Metric:      20      IP-Extended 10.2.1.0/30
Metric:      30      IP-Extended 10.3.2.0/30
Metric:      20      IP-Extended 10.4.1.0/30
Metric:      20      IP-Extended 10.4.2.0/30
Metric:      30      IP-Extended 10.33.1.0/30
Metric:      30      IP-Extended 10.33.44.0/30
Metric:      30      IP-Extended 10.44.5.0/30
PE1.03-00      * 0x00000001   0xA6CF   797   0/0/0
Metric:      0      IS-Extended PE1.00
Metric:      0      IS-Extended P1.00

```

```

PE1.04-00          * 0x00000001  0xB3C0      797          0/0/0
  Metric:    0          IS-Extended PE1.00
  Metric:    0          IS-Extended P2.00
PE2.00-00          0x00000008  0x9F4C      935          0/0/0
  Area Address: 49.0000
  NLPID:      0xCC
  Hostname:   PE2
  IP Address: 10.0.1.33
  Router ID:  10.0.1.33
  Router Cap: 10.0.1.33
    SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
    SR-Algorithm:
      Algorithm: 0
    SBFD Discriminator: 10.0.1.33
  Metric:    10          IS-Extended P4.03
  IPv4 Interface Address: 10.44.5.2
  Neighbor IP Address: 10.44.5.1
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0100.0000.1004 LAN Adjacency SID: 25600   F:0 B:0 V:1 L:1 S:0 P:0
  Metric:    10          IS-Extended P3.04
  IPv4 Interface Address: 10.33.1.1
  Neighbor IP Address: 10.33.1.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0100.0000.1003 LAN Adjacency SID: 25601   F:0 B:0 V:1 L:1 S:0 P:0
  Metric:    10          IP-Extended 10.0.1.33/32
    Prefix-SID: index 700 R:0 N:1 P:0 E:0 V:0 L:0
  Metric:    10          IP-Extended 10.44.5.0/30
  Metric:    10          IP-Extended 10.33.1.0/30
  Metric:    30          IP-Extended 10.0.1.1/32
    Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
  Metric:    30          IP-Extended 10.0.1.2/32
    Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
  Metric:    20          IP-Extended 10.0.1.3/32
    Prefix-SID: index 500 R:1 N:0 P:1 E:0 V:0 L:0
  Metric:    20          IP-Extended 10.0.1.4/32
    Prefix-SID: index 600 R:1 N:0 P:1 E:0 V:0 L:0
  Metric:    40          IP-Extended 10.0.1.11/32
    Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
  Metric:    20          IP-Extended 10.1.1.0/30
  Metric:    30          IP-Extended 10.1.2.0/30
  Metric:    20          IP-Extended 10.2.1.0/30
  Metric:    20          IP-Extended 10.3.2.0/30
  Metric:    20          IP-Extended 10.4.1.0/30
  Metric:    20          IP-Extended 10.4.2.0/30
  Metric:    30          IP-Extended 10.11.1.0/30
  Metric:    30          IP-Extended 10.11.2.0/30

```

```

Metric: 40      IP-Extended 10.11.22.0/30
Metric: 20      IP-Extended 10.33.44.0/30

```

```
PE1#
```

```
Validation 4
```

Verify that segment routing is enabled and that prefix SIDs are announced to other routers. Verify that prefix SIDs are installed as labels in MPLS forwarding table. Verify the same in FTN and ILM tables.

```
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							
i>	10.0.1.1/32	4	10	0	Yes	LSP_		
DEFAULT	16300 xe8	No	10.11.1.2					
i>	10.0.1.2/32	1	4	0	Yes	LSP_		
DEFAULT	16400 xe4	No	10.11.2.2					
i>	10.0.1.3/32	2	6	0	Yes	LSP_		
DEFAULT	16500 xe4	No	10.11.2.2					
i>	10.0.1.4/32	5	13	0	Yes	LSP_		
DEFAULT	16600 xe8	No	10.11.1.2					
P>	10.0.1.33/32	6	14	1	Yes	LSP_		
DEFAULT	16400 xe4	No	10.11.2.2					
i	10.0.1.33/32	3	7	0	Yes	LSP_		
DEFAULT	16700 xe4	No	10.11.2.2					

```
PE1#
```

In the forwarding tables above, the configured prefix SIDs are in the Out-Label column which is expected and is global across the topology. The swap happens in between nodes with this prefix SID and there is no local labelling. Also verify the ILM and FTN tables.

```
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

```

Code	FEC/VRF/L2CKT	ILM-ID	In-Label	Out-Label	In-Intf	Out-
Intf/VRF	Nexthop		LSP-Type			
i>	10.0.1.3/32	4	16500	16500	N/A	xe4 10.11
.2.2	LSP_DEFAULT					
i>	10.0.1.1/32	7	16300	16300	N/A	xe8 10.11
.1.2	LSP_DEFAULT					
i>	10.0.1.11/32	1	16100	Nolabel	N/A	N/A 127.0
.0.1	LSP_DEFAULT					
i>	10.0.1.2/32	6	16400	16400	N/A	xe4 10.11
.2.2	LSP_DEFAULT					
i>	10.11.2.2/32	2	26240	3	N/A	xe4 10.11
.2.2	LSP_DEFAULT					
i>	10.0.1.33/32	5	16700	16700	N/A	xe4 10.11
.2.2	LSP_DEFAULT					
i>	10.0.1.4/32	8	16600	16600	N/A	xe8 10.11
.1.2	LSP_DEFAULT					
P>	10.0.1.33/32	9	25600	16400	N/A	xe4 10.11
.2.2	LSP_DEFAULT					
i>	10.11.1.2/32	3	26241	3	N/A	xe8 10.11
.1.2	LSP_DEFAULT					

```

PE1#
PE1#
PE1#

```

```
PE1#show mpls ftn-table
Primary FTN entry with FEC: 10.0.1.1/32, id: 4, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 9, owner: ISIS-SR, Stale: NO, out intf: xe8, out label: 16300
Nexthop addr: 10.11.1.2          cross connect ix: 7, op code: Push

Primary FTN entry with FEC: 10.0.1.2/32, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: 3
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 3, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 16400
Nexthop addr: 10.11.2.2          cross connect ix: 4, op code: Push

Primary FTN entry with FEC: 10.0.1.3/32, id: 2, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: 5
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 5, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 16500
Nexthop addr: 10.11.2.2          cross connect ix: 5, op code: Push

Primary FTN entry with FEC: 10.0.1.4/32, id: 5, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: 12
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 12, owner: ISIS-SR, Stale: NO, out intf: xe8, out label: 16600
Nexthop addr: 10.11.1.2          cross connect ix: 9, op code: Push

Primary FTN entry with FEC: 10.0.1.33/32, id: 6, row status: Active, Tunnel-Policy: N/A
Owner: SR_POLICY, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP:
none
Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: ocnos, Color: 0
Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 11
Owner: SR_POLICY, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 11, owner: SR_POLICY, Stale: NO, out intf: xe4, out label:
16400\16600\16700
Nexthop addr: 10.11.2.2          cross connect ix: 8, op code: Push

Bidirectional Forwarding Detection is configured
Bidirectional Forwarding Detection is enabled

Primary FTN entry with FEC: 10.0.1.33/32, id: 3, row status: Active, Tunnel-Policy: N/A
Owner: ISIS-SR, distance: 115, 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: 7
Owner: ISIS-SR, Persistent: No, Admin Status: Down, Oper Status: Down
Out-segment with ix: 7, owner: ISIS-SR, Stale: NO, out intf: xe4, out label: 16700
Nexthop addr: 10.11.2.2          cross connect ix: 6, op code: Push

PE1#
```


Validation 5

Verify that sr policy is enabled and up.

```

PE1#show segment-routing policy

Policy-Name          Color      End-
point               State      Forwarding-Info
ocnos                201      10.0.1.33      UP
16400/16600/16700/xe4

PE1#
PE1#
PE1#show segment-routing policy detail

Policy-Name: ocnos      Color 201      End-point 10.0.1.33      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:09:45
State Transition Count: 3
CSPF Retry Limit: 100      CSPF Retry Interval: 10
Binding SID :
BSID: 25600
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 200      Path Type: Explicit      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 3
Segment0[LABEL]: Label :16400
Segment1[LABEL]: Label :16600
Segment2[LABEL]: Label :16700
Out-if: xe4      Out-label-stack: 16400/16600/16700
Attributes:
Configured:
Explicit segment-list Name: PE3

PE1#

```

Validation 6

Verify that s-bfd session is enabled and up.

```

PE1#show bfd session

BFD process for VRF: (DEFAULT VRF)
=====
Sess-Idx  Remote-Disc  Lower-Layer  Sess-Type  Sess-State  UP-Time  Interface  Down-
Reason  Remote-Addr
1281      10.0.1.33    MPLS LSP     Single-    Up          00:10:45  xe4        NA
Hop Up                                     10.0.1.33/32

Number of Sessions: 1
PE1#
PE1#
PE1#show bfd session detail

BFD process for VRF: (DEFAULT VRF)
=====

Session Interface Index : 10005      Interface name :xe4
Session Index : 1281
Lower Layer : MPLS LSP      Version : 1
Session Type : Single Hop    Session State : Up

```

```

Local Discriminator : 1281
Remote Discriminator : 10.0.1.33
Local Port : 49153
LSP Owner : SR-POLICY
NHLFE Ix : 14
Options :

Diagnostics : None

Timers in Milliseconds :
Min Tx: 40           Min Rx: 0           Multiplier: 40
Neg Tx: 40           Neg Rx: 40           Neg detect mult: 40
Min echo Tx: 0       Min echo Rx: 0       Neg echo intrvl: 0
Storage type : 2
Sess down time : 00:00:00
Sess Down Reason : NA
Bfd GTSM Disabled
Bfd Authentication Disabled

Counters values:
Pkt In : n/a         Pkt Out : n/a
Echo Out : 00000000000000000000
IPv6 Pkt In : 00000000000000000000
UP Count : 1         UPTIME : 00:10:52

```

```
Protocol Client Info:
NSM-> Client ID: 1      Flags: 4
```

Number of Sessions: 1
PE1#

```
PE1#sh s-bfd discriminators
S-BFD Discriminators:
  10.0.1.3
  10.0.1.2
  10.0.1.1
  10.0.1.33
  10.0.1.4
```

PE1#

```
PE1#sh bfd mpls lsp sessions
```

Peer Addr		Path	Tunnel-					
name		State	Local	Local	Min	Min	Encap	Last Disc
ti	Tx		Rx	Dn-Time				Mul
10.0.1.33		Up	1281	40	40000	0	IP/UDP	00:00:00

PE1#

PE1#

PE1#

```
PE1#sh bfd mpls lsp clients
```

[illegible]

Segment Routing v6 Configuration

This section contains configurations of Segment Routing v6 (SRv6) with ISISv6.

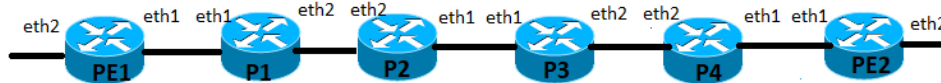
SRv6

SRv6 represents Segment routing (SR) with IPv6 data plane. The SRv6 network program is encoded in the Segment Routing extension Header (SRH) of a network packet as an ordered list of segments. The most significant bits of a segment are called "locator". The locator acts as any routed subnet address and ensures that the packet destined for a segment is routed to the destination of that segment. The packet goes from node to node and receives sequential processing according to ordered instructions selected by the source and encoded in the SRH. No intermediate node changes the flow.

Topology

Below topology is for SRv6 with ISISv6 configurations.

Figure 33. ISISv6 Configuration Topology



Configuration for ISISv6 with SRv6

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1(config)#tunnel-policy policy0	Configure tunnel policy
PE1(config-tnl-policy)#color 1	Color to be used as 1
PE1(config-tnl-policy)#exit	Exit to config mode
PE1(config)#ip vrf vrf1	IP VRF config with name vrf1
PE1(config-vrf)#tunnel-select-policy policy0	Tunnel-policy to be mapped as policy0
PE1(config-vrf)#rd 1:1	Route-distinguisher value
PE1(config-vrf)#route-target both 1:1	Route target value
PE1(config-vrf)#exit	Exit to config mode
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ipv6 address cafe:1:2::11/128	Configure IPv6 address of the loopback interface.
PE1(config-if)# ip address 1.1.1.1/32 secondary	Configure IP address on the loopback interface as

	secondary
PE1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface eth1	Enter interface mode.
PE1(config-if)#ipv6 address 1111::2/64	Configure the IPv6 address of the interface.
PE1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config)#interface eth2	Enter interface mode.
PE1(config-if)#ip vrf forwarding vrf1	Attaching eth2 to as part of vrf1
PE1(config-if)#ip address 101.1.1.1/24	Configure the IP address of the interface.
PE1(config-if)#exit	Exit interface mode
PE1(config)#router isis 1	Set the routing process ID as 1
PE1(config-router)#is-type level-2	Configure is-type as level-2
PE1(config-router)#metric-style wide	Configure wide metric-style
PE1(config-router)# net 49.0001.0000.0000.0001.00	Configure Network entity title (NET).
PE1(config-router)# address-family ipv6	Enter Address-family IPv6
PE1(config-router-af)#segment-routing srv6	Enable SRv6 under IPv6 address-family
PE1(config-router-af-srv6)# srv6-locator PE1_locator	Name to SRv6 locator
PE1(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE1(config-router-af)#exit-address-family	Exit address-family IPv6
PE1(config-router)#exit	Exit router mode.
PE1(config)# router bgp 1000	Configure router BGP in AS 1000
PE1(config-router)# neighbor cafe:1:2::22 remote-as 1000	Configure neighbor in remote-as 1000
PE1(config-router)#neighbor cafe:1:2::22 update-source lo	Configure neighbor with update-source lo
PE1(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE1(config-router-af)#neighbor cafe:1:2::22 activate	Activate VPNv4 neighbor
PE1(config-router-af)# neighbor cafe:1:2::22 capability extended-next-hop-encode	Configure extended nexthop encode capability for VPNv4 neighbor
PE1(config-router-af)#segment-routing srv6	Enter SRv6 mode
PE1(config-router-vpnv4-srv6)#srv6-locator PE1_locator	Locator name as PE1_locator
PE1(config-router-vpnv4-srv6)#exit-srv6	Exit from SRv6 configuration mode
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#address-family ipv4 vrf vrf1	Enter VRF address family

PE1(config-router-af)#redistribute connected	Redistribute connected routes
PE1(config-router-af)#segment-routing srv6	Enter SRv6 mode
PE1(config-router-vrfv4-srv6)#sid-alloc per-vrf	Allocate SID per VRF
PE1(config-router-vrfv4-srv6)#exit-srv6	Exit SRv6 mode
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#exit	Exit from router mode
PE1(config)#segment-routing	Configuring segment-routing
PE1(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
PE1(config-srv6)#locators	Configure SRv6 locators
PE1(config-srv6-loc)#locator PE1_locator	Locator name as PE1_locator
PE1(config-srv6-loc-conf)# prefix cafe:1:2:a11::/64	IPv6 prefix for locator
PE1(config-srv6-loc-conf)#exit-locator	Exit from locator mode
PE1(config-srv6-loc)#exit-locators	Exit from SRv6 locators configuration mode
PE1(config-srv6)#exit-srv6	Exit from SRv6 configuration mode
PE1(config-sr)#traffic-engineering	Segment Routing traffic engineering
PE1(config-sr-te)#segment-list 1	Configure segment list as 1
PE1(config-sr-sl)#index 1 segment-type-2 cafe:1:2:a22:2001::	Configure segment type 2 with SRv6 SIDs
PE1(config-sr-sl)#exit-sr-sl	Exit segment list mode
PE1(config-sr-te)#policy 1	Policy configuration with name 1
PE1(config-sr-pol)#color 1 end-point cafe:1:2::22	SR-policy color and end-point
PE1(config-sr-pol)#candidate-path 1	SR policy candidate path
PE1(config-sr-pol-cp)#preference 100	Candidate Path preference
PE1(config-sr-pol-cp)#explicit segment-list 1	Dynamic candidate path as ISIS
PE1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path
PE1(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode
PE1(config-sr-te)#exit-te	Exit from traffic engineering configuration mode
PE1(config-sr)#exit	Exit from SR mode

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#interface eth1	Enter interface mode.
P1(config-if)# ipv6 address 1111::1/64	Configure the IPv6 address of the interface.
P1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1

	instance.
P1(config)#interface eth2	Enter interface mode.
P1(config-if)# ipv6 address 5001::1/64	Configure the IP address of the interface.
P1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#exit	Exit interface mode.
P1(config)#router isis 1	Set the routing process ID as 1
P1(config-router)#is-type level-2	Configure is-type as level-2
P1(config-router)#metric-style wide	Configure wide metric-style
P1(config-router)# net 49.0001.0000.0000.0002.00	Configure Network entity title (NET).
P1(config-router)# address-family ipv6	Enter Address-family IPv6
P1(config-router-af)#exit-address-family	Exit address family IPv6
P1(config-router)#exit	Exit router mode.

P2

The following are the step-by-step configurations on the P2 router.

P2#configure terminal	Enter configure mode.
P2(config)#interface eth1	Enter interface mode.
P2(config-if)# ipv6 address 50::50/64	Configure the IPv6 address of the interface.
P2(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config)#interface eth2	Enter interface mode.
P2(config-if)# ipv6 address 5001::2/64	Configure the IP address of the interface.
P2(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P2(config-if)#exit	Exit interface mode.
P2(config)#router isis 1	Set the routing process ID as 1
P2(config-router)#is-type level-2	Configure is-type as level-2
P2(config-router)#metric-style wide	Configure wide metric-style
P2(config-router)# net 49.0001.0000.0000.0003.00	Configure Network entity title (NET).
P2(config-router)# address-family ipv6	Enter Address-family IPv6
P2(config-router-af)#exit-address-family	Exit address family IPv6
P2(config-router)#exit	Exit router mode.

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#interface eth1	Enter interface mode.
P3(config-if)# ipv6 address 50::5/64	Configure the IPv6 address of the interface.
P3(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config)#interface eth2	Enter interface mode.
P3(config-if)# ipv6 address 511::1/64	Configure the IP address of the interface.
P3(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P3(config-if)#exit	Exit interface mode.
P3(config)#router isis 1	Set the routing process ID as 1
P3(config-router)#is-type level-2	Configure is-type as level-2
P3(config-router)#metric-style wide	Configure wide metric-style
P3(config-router)# net 49.0001.0000.0000.0004.00	Configure Network entity title (NET).
P3(config-router)# address-family ipv6	Enter Address-family IPv6
P3(config-router-af)#exit-address-family	Exit address family IPv6
P3(config-router)#exit	Exit router mode.

P4

The following are the step-by-step configurations on the P4 router.

P4#configure terminal	Enter configure mode.
P4(config)#interface eth1	Enter interface mode.
P4(config-if)# ipv6 address 611::1/64	Configure the IPv6 address of the interface.
P4(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P4(config)#interface eth2	Enter interface mode.
P4(config-if)# ipv6 address 511::2/64	Configure the IP address of the interface.
P4(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P4(config-if)#exit	Exit interface mode.
P4(config)#router isis 1	Set the routing process ID as 1
P4(config-router)#is-type level-2	Configure is-type as level-2
P4(config-router)#metric-style wide	Configure wide metric-style
P4(config-router)# net 49.0001.0000.0000.0005.00	Configure Network entity title (NET).
P4(config-router)# address-family ipv6	Enter Address-family IPv6

P4(config-router-af)#exit-address-family	Exit address family IPv6
P4(config-router)#exit	Exit router mode.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#tunnel-policy policy0	Configure tunnel policy
PE2(config-tnl-policy)#color 1	Color to be used as 1
PE2(config-tnl-policy)#exit	Exit to config mode
PE2(config)#ip vrf vrf1	IP VRF config with name vrf1
PE2(config-vrf)#tunnel-select-policy policy0	Tunnel-policy to be mapped as policy0
PE2(config-vrf)#rd 1:2	Route-distinguisher value
PE2(config-vrf)#route-target both 1:1	Route target value
PE2(config-vrf)#exit	Exit to config mode
PE2(config)#interface lo	Enter interface mode.
PE2(config-if)# ip address 6.6.6.6/32 secondary	Configure IP address on the loopback interface as secondary
PE2(config-if)#ipv6 address cafe:1:2::22/128	Configure IPv6 address of the loopback interface.
PE2(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#interface eth1	Enter interface mode.
PE2(config-if)#ipv6 address 611::2/64	Configure the IPv6 address of the interface.
PE2(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE2(config)#interface eth2	Enter interface mode.
PE2(config-if)#ip vrf forwarding vrf1	Attaching eth2 to as part of vrf1
PE2(config-if)#ip address 201.1.1.1/24	Configure the IP address of the interface.
PE2(config-if)#exit	Exit interface mode
PE2(config)#router isis 1	Set the routing process ID as 1
PE2(config-router)#is-type level-2	Configure is-type as level-2
PE2(config-router)#metric-style wide	Configure wide metric-style
PE2(config-router)# net 49.0001.0000.0000.0006.00	Configure Network entity title (NET).
PE2(config-router)# address-family ipv6	Enter Address-family IPv6
PE2(config-router-af)#segment-routing srv6	Enable SRv6 under IPv6 address-family

PE2(config-router-af-srv6)# srv6-locator PE2_locator	Name to SRv6 locator
PE2(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE2(config-router-af)#exit-address-family	Exit address-family IPv6
PE2(config-router)#exit	Exit router mode.
PE2(config)# router bgp 1000	Configure router BGP in AS 1000
PE2(config-router)# neighbor cafe:1:2::11 remote-as 1000	Configure neighbor in remote-as 1000
PE2(config-router)#neighbor cafe:1:2::11 update-source lo	Configure neighbor with update-source lo
PE2(config-router)# address-family vpnv4 unicast	Enter VPNv4 Address family mode
PE2(config-router-af)#neighbor cafe:1:2::11 activate	Activate VPNv4 neighbor
PE2(config-router-af)# neighbor cafe:1:2::11 capability extended-nexthop-encode	Configure extended nexthop encode capability for VPNv4 neighbor
PE2(config-router-af)# segment-routing srv6	Enter SRv6 mode
PE2(config-router-vpnv4-srv6)# srv6-locator PE2_locator	Configure locator name under SRv6 mode
PE2(config-router-vpnv4-srv6)# exit-srv6	Exit SRv6 mode
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#address-family ipv4 vrf vrf1	Enter VRF address family
PE2(config-router-af)#redistribute connected	Redistribute connected routes
PE2(config-router-af)#segment-routing srv6	Enter SRv6 mode
PE2(config-router-vrfv4-srv6)#sid-alloc per-vrf	Allocate SID per VRF
PE2(config-router-vrfv4-srv6)#exit-srv6	Exit SRv6 mode
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#exit	Exit from router mode
PE2(config)#segment-routing	Configuring segment-routing
PE2(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
PE2(config-srv6)#locators	Configure SRv6 locators
PE2(config-srv6-loc)#locator PE2_locator	Locator name as PE2_locator
PE2(config-srv6-loc-conf)# prefix cafe:1:2:a11::/64	IPv6 prefix for locator
PE2(config-srv6-loc-conf)#exit-locator	Exit from locator mode
PE2(config-srv6-loc)#exit-locators	Exit from SRv6 locators configuration mode
PE2(config-srv6)#exit-srv6	Exit from SRv6 configuration mode
PE2(config-sr)#traffic-engineering	Segment Routing traffic engineering
PE2(config-sr-te)#segment-list 1	Configure segment list as 1
PE2(config-sr-sl)#index 1 segment-type-2 cafe:1:2:a22:2001::	Configure segment type 2 with SRv6 SIDs

PE2(config-sr-sl)#exit-sr-sl	Exit segment list mode
PE2(config-sr-te)#policy 1	Policy configuration with name 1
PE2(config-sr-pol)# color 1 end-point cafe:1:2::11	SR-policy color and end-point
PE2(config-sr-pol)#candidate-path 1	SR policy candidate path
PE2(config-sr-pol-cp)#preference 100	Candidate Path preference
PE2(config-sr-pol-cp)# explicit segment-list 1	Configuring explicit segment-list as 1
PE2(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path
PE2(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode
PE2(config-sr-te)#exit-te	Exit from traffic engineering configuration mode
PE2(config-sr)#exit	Exit from SR mode

Validation

PE1

Verify PE1 Router

```

PE1#show clns neighbors
Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
0000.0000.0002 eth1      b86a.97d6.716e    Up     24        L2    IS-IS

PE1#sho ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 1000
BGP table version is 2
1 BGP AS-PATH entries
0 BGP community entries

Neighbor          V  AS  MsgRcv  MsgSen  TblVer  InQ  OutQ  Up/Down  State/PfxRcd
cafe:1:2::22      4 1000  132     193     2       0     0  00:33:04      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, 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 vrf1)
*> 101.1.1.0/24     0.0.0.0            0         100       32768  ?
*>i201.1.1.0        cafe:1:2::22        0         100       0  ?
  Announced routes count = 1
  Accepted routes count = 1
Route Distinguisher: 1:2
*>i201.1.1.0        cafe:1:2::22        0         100       0  ?
  Announced routes count = 0

```

```

Accepted routes count = 1
PE1#
PE1#show segment-routing srv6 services
Codes: > - installed; T:Uses service-mapped tunnel
Service Flags
vrf      FEC      SID      Nexthop      SRv6-
Policy-Name
vpnrv4   >T      vrf1      201.1.1.0/24  cafe:1:2:a22:8001::  cafe:1:2::22
1

PE1# show segment-routing srv6 sid
SRv6 Segment ID table:
SID      Operation      Nexthop      Originator
+-----+-----+-----+-----+
cafe:1:2:a11:801::  END[usd]      ::           nsm
cafe:1:2:a11:1001::  END[usp]      ::           nsm
cafe:1:2:a11:2001::  END[psp]      ::           nsm
cafe:1:2:a11:6001::  END.X[psp]    fe80::ba6a:97ff:fed6:716eisis
cafe:1:2:a11:8001::  END.DT4      vrf vrf1     bgp:1000
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,
P - SRV6-POLICY, v - vrf leaked
Timers: Uptime
IP Route Table for VRF "default"
C      ::1/128 via ::, lo, 00:45:32
i L2   50::/64 [115/30] via fe80::ba6a:97ff:fed6:716e, eth1, 00:38:19
i L2   511::/64 [115/40] via fe80::ba6a:97ff:fed6:716e, eth1, 00:38:19
i L2   611::/64 [115/50] via fe80::ba6a:97ff:fed6:716e, eth1, 00:38:19
C      1111::/64 via ::, eth1, 00:38:50
i L2   5001::/64 [115/20] via fe80::ba6a:97ff:fed6:716e, eth1, 00:38:19
C      cafe:1:2::11/128 via ::, lo, 00:38:50
i L2   cafe:1:2::22/128 [115/60] via fe80::ba6a:97ff:fed6:716e, eth1, 00:37:29
C      cafe:1:2:a11:801::/128, SRV6 END SID
via ::, lo, 00:38:50
C      cafe:1:2:a11:1001::/128, SRV6 END SID
via ::, lo, 00:38:50
C      cafe:1:2:a11:2001::/128, SRV6 END SID
via ::, lo, 00:38:50
C      cafe:1:2:a11:6001::/128, SRV6 END.X SID
via fe80::ba6a:97ff:fed6:716e, eth1, 00:38:34
C      cafe:1:2:a11:8001::/128, SRV6 END.DT4 SID
via ::, lo, 00:38:50
i L2   cafe:1:2:a22::/64 [115/51] via fe80::ba6a:97ff:fed6:716e, eth1, 00:37:29
C      fe80::/64 via ::, eth1, 00:44:30

PE1#show isis database detail
Tag 1: VRF : default
IS-IS Level-2 Link State Database:
LSPID      LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00* 0x00000005   0xFC0C       681           0/0/0
Area Address: 49.0001
NLPID:     0x8E
IPv6 Address: 1111::2
Router Cap: 0.0.0.0
SR-Algorithm:
Algorithm: 0
Maximum SID Depth:
SRH maximum segments left : 4
SRH maximum end pop : 4
SRH maximum H.encaps : 4
SRH maximum decapsulation sids : 4
SRV6 flags: 0
Metric:    10      IS-Extended 0000.0000.0001.01

```

```

Metric: 10      IPv6 1111::/64
Metric: 10      IPv6 cafe:1:2::11/128
Metric: 1        IPv6 cafe:1:2:a11::/64
SRV6 Locator:   (IPv6)cafe:1:2:a11::/64
  Algorithm: 0  flags: 0  metric: 0
    END SID: cafe:1:2:a11:2001::  flags:0  End-point behaviour: End with PSP (2)
    END SID: cafe:1:2:a11:1001::  flags:0  End-point behaviour: End with USP (3)
    END SID: cafe:1:2:a11:801::  flags:0  End-point behaviour: End with USD (28)
0000.0000.0001.01-00* 0x00000003  0x8D3B      681      0/0/0
  Metric: 0        IS-Extended 0000.0000.0001.00
  Metric: 0        IS-Extended 0000.0000.0002.00
0000.0000.0002.00-00 0x00000004  0xBCAD      684      0/0/0
  Area Address: 49.0001
  NLPID: 0x8E
  IPv6 Address: 5001::1
  Metric: 10      IS-Extended 0000.0000.0001.01
  Metric: 10      IS-Extended 0000.0000.0003.02
  Metric: 10      IPv6 5001::/64
0000.0000.0003.00-00 0x00000004  0x234D      687      0/0/0
  Area Address: 49.0001
  NLPID: 0x8E
  IPv6 Address: 50::50
  Metric: 10      IS-Extended 0000.0000.0003.02
  Metric: 10      IS-Extended 0000.0000.0003.01
  Metric: 10      IPv6 50::/64
  Metric: 10      IPv6 5001::/64
0000.0000.0003.01-00 0x00000003  0xB70B      686      0/0/0
  Metric: 0        IS-Extended 0000.0000.0003.00
  Metric: 0        IS-Extended 0000.0000.0004.00
0000.0000.0003.02-00 0x00000003  0x883B      683      0/0/0
  Metric: 0        IS-Extended 0000.0000.0003.00
  Metric: 0        IS-Extended 0000.0000.0002.00
0000.0000.0004.00-00 0x00000004  0xFDF5      690      0/0/0
  Area Address: 49.0001
  NLPID: 0x8E
  IPv6 Address: 50::5
  Metric: 10      IS-Extended 0000.0000.0003.01
  Metric: 10      IS-Extended 0000.0000.0005.02
  Metric: 10      IPv6 50::/64
  Metric: 10      IPv6 511::/64
0000.0000.0005.00-00 0x00000004  0xE87D      693      0/0/0
  Area Address: 49.0001
  NLPID: 0x8E
  IPv6 Address: 611::1
  Metric: 10      IS-Extended 0000.0000.0005.02
  Metric: 10      IS-Extended 0000.0000.0006.01
  Metric: 10      IPv6 611::/64
  Metric: 10      IPv6 511::/64
0000.0000.0005.02-00 0x00000003  0xB20B      689      0/0/0
  Metric: 0        IS-Extended 0000.0000.0005.00
  Metric: 0        IS-Extended 0000.0000.0004.00
0000.0000.0006.00-00 0x00000004  0xB1E9      697      0/0/0
  Area Address: 49.0001
  NLPID: 0x8E
  IPv6 Address: 611::2
  Router Cap: 0.0.0.0
  SR-Algorithm:
    Algorithm: 0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  Metric: 10      IS-Extended 0000.0000.0006.01
  Metric: 10      IPv6 611::/64
  Metric: 10      IPv6 cafe:1:2::22/128
  Metric: 1        IPv6 cafe:1:2:a22::/64

```

```
SRV6 Locator:      (IPv6)cafe:1:2:a22::/64
Algorithm: 0  flags: 0  metric: 0
END SID: cafe:1:2:a22:2001::  flags:0  End-point behaviour: End with PSP (2)
END SID: cafe:1:2:a22:1001::  flags:0  End-point behaviour: End with USP (3)
END SID: cafe:1:2:a22:801::  flags:0  End-point behaviour: End with USD (28)
0000.0000.0006.01-00  0x00000003  0xCEEC  694  0/0/0
Metric:  0  IS-Extended 0000.0000.0006.00
Metric:  0  IS-Extended 0000.0000.0005.00
```

Configuring SRv6 EVPN ELINE

This section contains configurations of SRv6 EVPN ELINE Single Homing and Multihoming.

SRv6 EVPN ELINE Single Homing

EVPN E-LINE provides a P2P L2VPN service solution based on the EVPN service architecture. Regarding this solution, a P2P SRv6 tunnel is established between PEs and traverses the backbone network. By binding the AC interface on the user side to the P2P SRv6 tunnel on the network side, traffic can be transmitted between the AC interface and the P2P SRv6 tunnel. As a result, traffic that enters the AC interface is forwarded directly to the peer PE through the P2P SRv6 tunnel. This solution provides a simple Layer 2 packet forwarding mode for the connection between AC interfaces at both ends, avoiding the need to search MAC address entries. This service solution is named Ethernet Line (E-Line).

Topology

Below example shows the SRv6 EVPN ELINE Single Homing configurations.

Figure 34. SRv6 EVPN ELINE Single Homing Topology



SRV6 EVPN ELINE SH Configuration without Policy

PE1

The following are the step-by-step configurations on the PE1 router for Loopback Interface

PE1#configure terminal	Enter configure mode.
PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ipv6 address cafe:1:2::11/128	Configure IPv6 address of the loopback interface.
PE1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#exit	Exit interface mode.

The following are the step-by-step configurations on the PE1 router for Global SRv6 EVPN Command

PE1#configure terminal	Enter configure mode.
PE1(config)#evpn srv6 enable	Enable srv6 evpn under config mode
PE1(config)#evpn srv6 ip-global cafe:1:2::11	Configuring SRv6 global IP to loopback IP
PE1(config)#qos enable	Enable qos

The following are the step-by-step configurations on the PE1 router for Interface Configuration Network Side

PE1(config)#interface ce16	Enter interface mode.
PE1(config-if)#ipv6 address 5001::1/64	Configure the IPv6 address of the interface.
PE1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#exit	Exit the interface

The following are the step-by-step configurations on the PE1 router for ISIS Configuration

PE1(config)#router isis 1	Set the routing process ID as 1
PE1(config-router)#is-type level-2-only	Configure isis level2
PE1(config-router)#metric-style wide	Configure wide metric-style
PE1(config-router)#net 49.0001.0000.0000.0001.00	Configure Network entity title (NET).
PE1(config-router)#address-family ipv6	Enter Address-family IPv6
PE1(config-router-af)#segment-routing srv6	Enter into segment routing SRv6 mode
PE1(config-router-af-srv6)#srv6-locator PE1_locator	Configure SRv6 locator name
PE1(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE1(config-router-af)#exit	Exit address family mode
PE1(config-router)#exit	Exit router mode.

The following are the step-by-step configurations on the PE1 router for BGP Configuration

PE1(config)#router bgp 1000	Configure router BGP in AS 1000
PE1(config-router)#bgp router-id 1.1.1.1	Configure BGP Router ID
PE1(config-router)#neighbor cafe:1:2::22 remote-as 1000	Configure neighbor remote-as 1000
PE1(config-router)#neighbor cafe:1:2::22 update-source lo	Configure neighbor with update-source lo
PE1(config-router)#address-family l2vpn evpn	Configure address-family l2vpn evpn
PE1(config-router-af)#neighbor cafe:1:2::22 activate	Activate neighbor under l2vpn evpn address family
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#exit	Exit router prompt

The following are the step-by-step configurations on the PE1 router for MAC VRF Configuration

PE1#configure terminal	Enter configure mode.
PE1(config)#mac vrf vrf3	Configure first mac VRF with name vrf3
PE1(config-vrf)#rd 1.1.1.1:30	Configure Route-distinguisher value
PE1(config-vrf)#route-target both 30:30	Configure Route target value
PE1(config-vrf)#exit	Exit to config mode
PE1(config)#mac vrf vrf4	Configure second mac VRF with name vrf4
PE1(config-vrf)#rd 1.1.1.1:40	Configure Route-distinguisher value
PE1(config-vrf)#route-target both 40:40	Configure Route target value
PE1(config-vrf)#exit	Exit to config mode

The following are the step-by-step configurations on the PE1 router for EVPN and MAC VRF Mapping

PE1#configure terminal	Enter into config mode
PE1(config)#evpn srv6 id 70 xconnect target-srv6-id 80	Configure the EVPN-ELINE identifier with source identifier 70 and target identifier 80
PE1(config-evpn-srv6)# evi-name eline-sh1	Configure evi-name as eline-sh1

PE1(config-evpn-srv6)#host-reachability-protocol evpn-bgp vrf3	Configure host reachable protocol to Ethernet-VPN over BGP
PE1(config-evpn-srv6)#locator PE1_locator	Configure Locator Name
PE1(config-evpn-srv6)#exit	Exit evpn srv6
PE1(config)#evpn srv6 id 71 xconnect target-srv6-id 81	Configure the EVPN-ELINE identifier with source identifier 71 and target identifier 81
PE1(config-evpn-srv6)#evi-name eline-sh2	Configure evi-name as eline-sh2
PE1(config-evpn-srv6)#host-reachability-protocol evpn-bgp vrf4	Configure host reachable protocol to Ethernet-VPN over BGP
PE1(config-evpn-srv6)#locator PE1_locator	Configure Locator Name
PE1(config-evpn-srv6)#exit	Exit evpn srv6
PE1(config)#interface ce15.100 switchport	Creating L2 sub interface of physical interface ce15
PE1(config-if)#encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100 Supported Encapsulation: dot1ad, dot1q, untagged, default
PE1(config-if)#access-if-evpn	Create the evpn mpls access-port
PE1(config-acc-if-evpn)#map vpn-id 70	Map vpn-id 70 to interface ce15.100 (ELINE)
PE1(config-acc-if-evpn)#exit	Exit evpn mapping mode
PE1(config-if)#exit	Exit evpn access mode
PE1(config)#interface ce15.101 switchport	Creating L2 sub interface of physical interface ce15
PE1(config-if)#encapsulation untagged	Setting Encapsulation to untagged Supported Encapsulation: dot1ad, dot1q, untagged, default
PE1(config-if)#access-if-evpn	Create the evpn mpls access-port
PE1(config-acc-if-evpn)#map vpn-id 71	Map vpn-id 71 to interface ce15.101 (ELINE)
PE1(config-acc-if-evpn)#exit	Exit evpn mapping mode
PE1(config-if)#exit	Exit evpn access mode

The following are the step-by-step configurations on the PE1 router for SRv6 Segment Routing

PE1(config)#segment-routing	Configuring segment-routing
PE1(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane

PE1 (config-srv6) #locators	Configure SRv6 locators
PE1 (config-srv6-loc) #locator PE1_locator	Locator name as PE1_locator
PE1 (config-srv6-loc-conf) #prefix cafe:1:2:all::/64	IPv6 prefix for locator
PE1 (config-srv6-loc-conf) #exit-locator	Exit from locator mode
PE1 (config-srv6-loc) #exit-locators	Exit from SRv6 locators configuration mode
PE1 (config-srv6) #exit-srv6	Exit from SRv6 configuration mode
PE1 (config-sr) #exit	Exit segment routing

P1

The following are the step-by-step configurations on the P1 router for Interface Configuration

P1#configure terminal	Enter configure mode.
P1 (config) #interface ce51	Enter interface mode.
P1 (config-if) #ipv6 address 5001::2/64	Configure the IPv6 address of the interface.
P1 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS 1 instance
P1 (config-if) #interface ce50	Enter interface mode.
P1 (config-if) #ipv6 address 3001::1/64	Configure the IP address of the interface.
P1 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P1 (config-if) #exit	Exit interface mode.

The following are the step-by-step configurations on the P1 router for ISIS Configuration

P1#configure terminal	Enter configure mode.
P1 (config) #router isis 1	Set the routing process ID as 1
P1 (config-router) #is-type level-2-only	Configure is-type as level-2
P1 (config-router) #metric-style wide	Configure wide metric-style
P1 (config-router) #net 49.0001.0000.0000.0002.00	Configure Network entity title (NET).
P1 (config-router) #address-family ipv6	Enter Address-family IPv6

P1 (config-router-af) #exit-address-family	Exit address family IPv6
P1 (config-router) #exit	Exit router mode.

PE2

The following are the step-by-step configurations on the PE2 router for Loopback Interface.

PE2#configure terminal	Enter configure mode.
PE2 (config) #interface lo	Enter interface mode.
PE2 (config-if) #ipv6 address cafe:1:2::22/128	Configure IPv6 address of the loopback interface.
PE2 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS instance 1
PE2 (config-if) #exit	Exit interface mode.

The following are the step-by-step configurations on the PE2 router for Global SRv6 EVPN Command.

PE2#configure terminal	Enter configure mode.
PE2 (config) #evpn srv6 enable	Enable srv6 evpn under config mode
PE2 (config) #evpn srv6 ip-global cafe:1:2::22	Configuring SRv6 global IP to loopback IP
PE1 (config) #qos enable	Enable qos

The following are the step-by-step configurations on the PE2 router for Interface Configuration Network Side

PE2 (config) #interface ce4	Enter interface mode.
PE2 (config-if) #ipv6 address 3001::2/64	Configure the IPv6 address of the interface.
PE2 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS instance 1
PE2 (config-if) #exit	Exit to config mode

The following are the step-by-step configurations on the PE2 router for ISIS Configuration

PE2(config)#router isis 1	Set the routing process ID as 1
PE2(config-router)#is-type level-2-only	Configure isis level-2
PE2(config-router)#metric-style wide	Configure wide metric-style
PE2(config-router)#net 49.0001.0000.0000.0003.00	Configure Network entity title (NET).
PE2(config-router)#address-family ipv6	Enter Address-family IPv6
PE2(config-router-af)#segment-routing srv6	Configure is-type as level-2
PE2(config-router-af-srv6)#srv6-locator PE2_locator	Name to SRv6 locator
PE2(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE2(config-router-af)#exit	Exit address family
PE2(config-router)#exit	Exit router mode.

The following are the step-by-step configurations on the PE2 router for BGP Configuration.

PE2(config)# router bgp 1000	Configure router BGP in AS 1000
PE2(config-router)# bgp router-id 2.2.2.2	Configure BGP Router ID
PE2(config-router)# neighbor cafe:1:2::11 remote-as 1000	Configure neighbor in remote-as 1000
PE2(config-router)#neighbor cafe:1:2::11 update-source lo	Configure neighbor with update-source lo
PE2(config-router)# address-family l2vpn evpn	Enter into l2vpn evpn Address family mode
PE2(config-router-af)#neighbor cafe:1:2::11 activate	Activate neighbor for EVPN under l2vpn address family
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#exit	Exit from router mode

The following are the step-by-step configurations on the PE2 router for MAC VRF Configuration.

PE2#configure terminal	Enter configure mode.
------------------------	-----------------------

PE2(config)#mac vrf vrf3	Configure first mac VRF with name vrf3
PE2(config-vrf)# rd 2.2.2.2:30	Configure Route-distinguisher value
PE2(config-vrf)# route-target both 30:30	Configure Route target value
PE2(config-vrf)#exit	Exit to config mode
PE2(config)#mac vrf vrf4	Configure second mac VRF with name vrf4
PE2(config-vrf)# rd 2.2.2.2:40	Configure Route-distinguisher value
PE2(config-vrf)# route-target both 40:40	Configure Route target value
PE2(config-vrf)#exit	Exit to config mode

The following are the step-by-step configurations on the PE2 router for EVPN and MAC VRF Mapping.

PE2#configure terminal	Enter into config mode
PE2(config)#evpn srv6 id 80 xconnect target-srv6-id 70	Configure the EVPN-ELINE identifier with source identifier 80 and target identifier 70
PE2(config-evpn-srv6)# evi-name eline-sh1	Configure evi-name as eline-sh1
PE2(config-evpn-srv6)# host-reachability-protocol evpn-bgp vrf3	Configure host reachable protocol to Ethernet-VPN over BGP
PE2(config-evpn-srv6)# locator PE2_locator	Configure Locator Name
PE2(config-evpn-srv6)#exit	Exit evpn srv6
PE2(config)#evpn srv6 id 81 xconnect target-srv6-id 71	Configure the EVPN-ELINE identifier with source identifier 81 and target identifier 71
PE2(config-evpn-srv6)# evi-name eline-sh2	Configure evi-name as eline-sh2
PE2(config-evpn-srv6)# host-reachability-protocol evpn-bgp vrf4	Configure host reachable protocol to Ethernet-VPN over BGP
PE2(config-evpn-srv6)# locator PE2_locator	Configure Locator Name
PE2(config-evpn-srv6)#exit	Exit evpn srv6
PE2(config)#interface ce6.100 switchport	Creating L2 sub interface of physical interface ce6
PE2(config-if)# encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100 Supported Encapsulation: dot1ad, dot1q, untagged, default

PE2 (config-if) # access-if-evpn	Create the evpn mpls access-port
PE2 (config-acc-if-evpn) #map vpn-id 80	Map vpn-id 80 to interface ce6.100 (ELINE)
PE2 (config-acc-if-evpn) #exit	Exit evpn mapping mode
PE2 (config-if) #exit	Exit evpn access mode
PE2 (config) #interface ce6.101 switchport	Creating L2 sub interface of physical interface ce6
PE2 (config-if) # encapsulation untagged	Setting Encapsulation to untagged Supported Encapsulation: dot1ad, dot1q, untagged, default
PE2 (config-if) # access-if-evpn	Create the evpn mpls access-port
PE2 (config-acc-if-evpn) # map vpn-id 81	Map vpn-id 81 to interface ce6.101 (ELINE)
PE2 (config-acc-if-evpn) #exit	Exit evpn mapping mode
PE2 (config-if) #exit	Exit evpn access mode

The following are the step-by-step configurations on the PE2 router for SRv6 Segment Routing.

PE2 (config) #segment-routing	Configuring segment-routing
PE2 (config-sr) #srv6	Segment-Routing over IPv6 Data-Plane
PE2 (config-srv6) #locators	Configure SRv6 locators
PE2 (config-srv6-loc) #locator PE2_ locator	Locator name as PE2_locator
PE2 (config-srv6-loc-conf) #prefix cafe:1:2:a22::/64	IPv6 prefix for locator
PE2 (config-srv6-loc-conf) #exit-locator	Exit from locator mode
PE2 (config-srv6-loc) #exit-locators	Exit from SRv6 locators configuration mode
PE2 (config-srv6) #exit-srv6	Exit from SRv6 configuration mode
PE2 (config-sr) #exit	Exit segment routing

Validation

SRV6 EVPN ELINE Validation without Policy

SRV6 ISIS Route Check

```
PE1#show clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
```

```

Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
0000.0000.0002 cel6      3c2c.99c9.09ad    Up     24        L2    IS-IS

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,
       P - SRV6-POLICY,
       v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C      ::1/128 via ::, lo, 00:17:59
i L2   3001::/64 [115/20] via fe80::3e2c:99ff:fec9:9ad, cel6, 00:11:49
C      5001::/64 via ::, cel6, 00:12:55
C      cafe:1:2::11/128 via ::, lo, 00:12:55
i L2   cafe:1:2::22/128 [115/30] via fe80::3e2c:99ff:fec9:9ad, cel6, 00:11:49
C      cafe:1:2:a11:2::/128, SRV6 END.DX2 SID
      via ::, lo, 00:12:55
C      cafe:1:2:a11:3::/128, SRV6 END.DX2 SID
      via ::, lo, 00:12:55
C      cafe:1:2:a11:801::/128, SRV6 END SID
      via ::, lo, 00:12:55
C      cafe:1:2:a11:1001::/128, SRV6 END SID
      via ::, lo, 00:12:55
C      cafe:1:2:a11:2001::/128, SRV6 END SID
      via ::, lo, 00:12:55
C      cafe:1:2:a11:6001::/128, SRV6 END.X SID
      via fe80::3e2c:99ff:fec9:9ad, cel6, 00:12:54
i L2   cafe:1:2:a22::/64 [115/21] via fe80::3e2c:99ff:fec9:9ad, cel6, 00:11:49
C      fe80::/64 via ::, cel5, 00:12:55

PE1#show isis database detail
Tag 1: VRF : default
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00* 0x0000000B  0x4560        430           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: 5001::1
  Router Cap:   0.0.0.0
  SR-Algorithm:
    Algorithm: 0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  Metric: 10      IS-Extended 0000.0000.0001.01
  Metric: 10      IPv6 5001::/64
  Metric: 10      IPv6 cafe:1:2::11/128
  Metric: 1       IPv6 cafe:1:2:a11::/64
  SRV6 Locator:   (IPV6)cafe:1:2:a11::/64
    Algorithm: 0 flags: 0 metric: 0
    END SID: cafe:1:2:a11:2001:: flags:0 End-point behaviour: End with PSP (2)
    END SID: cafe:1:2:a11:1001:: flags:0 End-point behaviour: End with USP (3)
    END SID: cafe:1:2:a11:801:: flags:0 End-point behaviour: End with USD (28)
0000.0000.0001.01-00* 0x00000001  0x9139        426           0/0/0
  Metric: 0       IS-Extended 0000.0000.0001.00
  Metric: 0       IS-Extended 0000.0000.0002.00
0000.0000.0002.00-00 0x00000013  0x814F        457           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E

```

```

IPv6 Address: 5001::2
Metric: 10          IS-Extended 0000.0000.0001.01
Metric: 10          IS-Extended 0000.0000.0003.02
Metric: 10          IPv6 5001::/64
Metric: 10          IPv6 3001::/64
0000.0000.0003.00-00 0x00000009 0xA707 462 0/0/0
Area Address: 49.0001
NLPID: 0x8E
IPv6 Address: cafe:1:2::22
Router Cap: 0.0.0.0
SR-Algorithm:
  Algorithm: 0
Maximum SID Depth:
  SRH maximum segments left : 4
  SRH maximum end pop : 4
  SRH maximum H.encaps : 4
  SRH maximum decapsulation sids : 4
SRV6 flags: 0
Metric: 10          IS-Extended 0000.0000.0003.02
Metric: 10          IPv6 cafe:1:2::22/128
Metric: 10          IPv6 3001::/64
Metric: 1           IPv6 cafe:1:2:a22::/64
SRV6 Locator: (IPv6)cafe:1:2:a22::/64
  Algorithm: 0 flags: 0 metric: 0
  END SID: cafe:1:2:a22:2001:: flags:0 End-point behaviour: End with PSP (2)
  END SID: cafe:1:2:a22:1001:: flags:0 End-point behaviour: End with USP (3)
  END SID: cafe:1:2:a22:801:: flags:0 End-point behaviour: End with USD (28)
0000.0000.0003.02-00 0x00000006 0x823E 458 0/0/0
Metric: 0          IS-Extended 0000.0000.0003.00
Metric: 0          IS-Extended 0000.0000.0002.00

PE2#show clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
0000.0000.0002 ce4        3c2c.99c9.09ac    Up     26        L2    IS-IS

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,
      P - SRV6-POLICY,
      v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C      ::1/128 via ::, lo, 00:12:30
C      3001::/64 via ::, ce4, 00:06:46
i L2   5001::/64 [115/20] via fe80::3e2c:99ff:fec9:9ac, ce4, 00:06:31
i L2   cafe:1:2::11/128 [115/30] via fe80::3e2c:99ff:fec9:9ac, ce4, 00:06:31
C      cafe:1:2::22/128 via ::, lo, 00:06:47
i L2   cafe:1:2:a11::/64 [115/21] via fe80::3e2c:99ff:fec9:9ac, ce4, 00:06:31
C      cafe:1:2:a22:2::/128, SRV6 END.DX2 SID
      via ::, lo, 00:06:47
C      cafe:1:2:a22:3::/128, SRV6 END.DX2 SID
      via ::, lo, 00:06:47
C      cafe:1:2:a22:801::/128, SRV6 END SID
      via ::, lo, 00:06:47
C      cafe:1:2:a22:1001::/128, SRV6 END SID
      via ::, lo, 00:06:47
C      cafe:1:2:a22:2001::/128, SRV6 END SID
      via ::, lo, 00:06:47
C      cafe:1:2:a22:6001::/128, SRV6 END.X SID

```



```

    via fe80::3e2c:99ff:fec9:9ac, ce4, 00:06:46
C    fe80::/64 via ::, ce4, 00:06:46

PE2#show isis database detail
Tag 1: VRF : default
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00  0x0000000B  0x4560        760           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: 5001::1
  Router Cap:   0.0.0.0
  SR-Algorithm:
    Algorithm: 0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  Metric: 10      IS-Extended 0000.0000.0001.01
  Metric: 10      IPv6 5001::/64
  Metric: 10      IPv6 cafe:1:2::11/128
  Metric: 1       IPv6 cafe:1:2:a11::/64
  SRV6 Locator:   (IPv6)cafe:1:2:a11::/64
    Algorithm: 0  flags: 0  metric: 0
    END SID: cafe:1:2:a11:2001:: flags:0 End-point behaviour: End with PSP (2)
    END SID: cafe:1:2:a11:1001:: flags:0 End-point behaviour: End with USP (3)
    END SID: cafe:1:2:a11:801:: flags:0 End-point behaviour: End with USD (28)
0000.0000.0001.01-00  0x00000001  0x9139        756           0/0/0
  Metric: 0       IS-Extended 0000.0000.0001.00
  Metric: 0       IS-Extended 0000.0000.0002.00
0000.0000.0002.00-00  0x00000013  0x814F        788           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: 5001::2
  Metric: 10      IS-Extended 0000.0000.0001.01
  Metric: 10      IS-Extended 0000.0000.0003.02
  Metric: 10      IPv6 5001::/64
  Metric: 10      IPv6 3001::/64
0000.0000.0003.00-00* 0x00000009  0xA707        793           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: cafe:1:2::22
  Router Cap:   0.0.0.0
  SR-Algorithm:
    Algorithm: 0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  Metric: 10      IS-Extended 0000.0000.0003.02
  Metric: 10      IPv6 cafe:1:2::22/128
  Metric: 10      IPv6 3001::/64
  Metric: 1       IPv6 cafe:1:2:a22::/64
  SRV6 Locator:   (IPv6)cafe:1:2:a22::/64
    Algorithm: 0  flags: 0  metric: 0
    END SID: cafe:1:2:a22:2001:: flags:0 End-point behaviour: End with PSP (2)
    END SID: cafe:1:2:a22:1001:: flags:0 End-point behaviour: End with USP (3)
    END SID: cafe:1:2:a22:801:: flags:0 End-point behaviour: End with USD (28)
0000.0000.0003.02-00* 0x00000006  0x823E        790           0/0/0
  Metric: 0       IS-Extended 0000.0000.0003.00
  Metric: 0       IS-Extended 0000.0000.0002.00

```

BGP

Validation for EVPN-ELINE SH

```
PE1#show bgp neighbors
BGP neighbor is cafe:1:2::22, remote AS 1000, local AS 1000, internal link
  BGP version 4, local router ID 1.1.1.1, remote router ID 2.2.2.2
  BGP state = Established, up for 00:12:10
  Last read 00:00:12, 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 36 messages, 0 notifications, 0 in queue
  Sent 35 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 7, neighbor version 7
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  2 accepted prefixes
  Accepted AD:2 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  2 announced prefixes

Connections established 1; dropped 0
Local host: cafe:1:2::11, Local port: 37131
Foreign host: cafe:1:2::22, Foreign port: 179
Nexthop: 1.1.1.1
Nexthop global: cafe:1:2::11
Nexthop local: ::
BGP connection: non shared network

PE2#show bgp neighbors
BGP neighbor is cafe:1:2::11, remote AS 1000, local AS 1000, internal link
  BGP version 4, local router ID 2.2.2.2, remote router ID 1.1.1.1
  BGP state = Established, up for 00:06:35
  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 L2VPN EVPN: advertised and received
  Received 19 messages, 0 notifications, 0 in queue
  Sent 20 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 2, neighbor version 2
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  2 accepted prefixes
  Accepted AD:2 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  2 announced prefixes

Connections established 1; dropped 0
Local host: cafe:1:2::22, Local port: 179
Foreign host: cafe:1:2::11, Foreign port: 37131
Nexthop: 2.2.2.2
Nexthop global: cafe:1:2::22
Nexthop local: ::
BGP connection: non shared network
```

PE1

Validation on SRV6 EVPN-ELINE

```

PE1#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:

EVPN:
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID      Nexthop      SRv6-Policy-Name
ELINE   >      vrf3      70            80            cafe:1:2:a22:2::      cafe:1:2::
22      None
ELINE   >      vrf4      71            81            cafe:1:2:a22:3::      cafe:1:2::
22      None

PE1#show segment-routing srv6 services evpn
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID      Nexthop      SRv6-Policy-Name
ELINE   >      vrf3      70            80            cafe:1:2:a22:2::      cafe:1:2::
22      None
ELINE   >      vrf4      71            81            cafe:1:2:a22:3::      cafe:1:2::
22      None

PE1#show segment-routing srv6 sid
SRv6 Segment ID table:
SID      Operation      Nexthop      Originator
+-----+-----+-----+-----+
cafe:1:2:a11:2::  END.DX2      ::          evpn:70
cafe:1:2:a11:3::  END.DX2      ::          evpn:71
cafe:1:2:a11:801::  END[usd]     ::          nsm
cafe:1:2:a11:1001::  END[usp]     ::          nsm
cafe:1:2:a11:2001::  END[psp]     ::          nsm
cafe:1:2:a11:6001::  END.X[psp]   fe80::3e2c:99ff:fec9:9ad  isis

PE1#show hsl srv6 evpn
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+
71      cafe:1:2::22      0 /PRI
/1      ce16      fe80::3e2c:99ff:fec9:9ad      cafe:1:2:a22:3::      Active      0x2000ccdf
70      cafe:1:2::22      0 /PRI
/1      ce16      fe80::3e2c:99ff:fec9:9ad      cafe:1:2:a22:2::      Active      0x2000ccdd

PE1#show hsl srv6 evpn 70
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+
70      cafe:1:2::22      0 /PRI
/1      ce16      fe80::3e2c:99ff:fec9:9ad      cafe:1:2:a22:2::      Active      0x2000ccdd

PE1#show hsl srv6 evpn 71
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |

```

```

SEGMENT      | CACHE | FEC_ID |
| ID |      FEC      | TYPE/NHLFE-ID | IFNAME
|-----|-----|-----|-----|-----|
+-----+-----+-----+-----+-----+
71      cafe:1:2::22      0 /PRI
/1      ce16      fe80::3e2c:99ff:fec9:9ad      cafe:1:2:a22:3::      Active      0x2000ccdf

```

```

PE1#show evpn srv6 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				
70	eline-sh1	1500	80	ce15.100	---	Single Homed Port ---	
	cafe:1:2::22	1500	AC-NW NW-SET				
71	eline-sh2	1500	81	ce15.101	---	Single Homed Port ---	
	cafe:1:2::22	1500	AC-NW NW-SET				

Total number of entries are 2

```

PE1#show evpn srv6 xconnect id 70
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				
70	eline-sh1	1500	80	ce15.100	---	Single Homed Port ---	
	cafe:1:2::22	1500	AC-NW NW-SET				

Total number of entries are 1

```

PE1#show evpn srv6 xconnect id 71
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				

```
=====
71          eline-sh2      1500  81          ce15.101      --- Single Homed Port ---
      cafe:1:2::22      1500  AC-NW  NW-SET
```

Total number of entries are 1

PE1#show evpn srv6 xconnect tunnel summary

Total number of entries: 2 [Installed: 2, Resolved: 0, Unresolved: 0]

PE1#show evpn srv6 xconnect tunnel sid

EVPN-SRV6 Network tunnel SID's

Evpn service type: ELINE

EVI-NAME: NA

PE IP: cafe:1:2::22

Status: Installed

Xconnect information

Local Ethernet Tag Id: 70

Local UC-SID: cafe:1:2:a11:2::

Remote Ethernet Tag Id: 80

Remote UC-SID: cafe:1:2:a22:2::

Tunnel policy mapped: --

Evpn service type: ELINE

EVI-NAME: NA

PE IP: cafe:1:2::22

Status: Installed

Xconnect information

Local Ethernet Tag Id: 71

Local UC-SID: cafe:1:2:a11:3::

Remote Ethernet Tag Id: 81

Remote UC-SID: cafe:1:2:a22:3::

Tunnel policy mapped: --

Total number of entries are 2

PE2#show segment-routing srv6 services

Status codes: > - installed, * - selected, T - Uses service-mapped tunnel

L3VPN:

EVPN:

Service	Flags	vrf	local-evpn-id	remote-evpn-	SRv6-Policy-Name	
id	SID		Nextthop			
ELINE	>	vrf3	80	70	cafe:1:2:a11:2::	cafe:1:2::
11		None				
ELINE	>	vrf4	81	71	cafe:1:2:a11:3::	cafe:1:2::
11		None				

PE2#show segment-routing srv6 services evpn

Status codes: > - installed, * - selected, T - Uses service-mapped tunnel

Service	Flags	vrf	local-evpn-id	remote-evpn-	SRv6-Policy-Name	
id	SID		Nextthop			
ELINE	>	vrf3	80	70	cafe:1:2:a11:2::	cafe:1:2::
11		None				
ELINE	>	vrf4	81	71	cafe:1:2:a11:3::	cafe:1:2::
11		None				

PE2#show segment-routing srv6 sid

SRv6 Segment ID table:

SID	Operation	Nextthop	Originator
cafe:1:2:a22:2::	END.DX2	::	evpn:80
cafe:1:2:a22:3::	END.DX2	::	evpn:81
cafe:1:2:a22:801::	END[usd]	::	nsm
cafe:1:2:a22:1001::	END[usp]	::	nsm
cafe:1:2:a22:2001::	END[psp]	::	nsm
cafe:1:2:a22:6001::	END.X[psp]	fe80::3e2c:99ff:fec9:9ac	isis

PE2#show hsl srv6 evpn

TABLE: SRV6 EVPN Table

-----+-----+-----+-----+-----+-----+-----						
-----+-----+-----+-----+-----+-----+-----						
EVPN SEGMENT	DESTINATION CACHE	POLICY-ID/ FEC_ID	OUT	NEXTHOP	EVPN	
ID	FEC	TYPE/NHLFE-ID	IFNAME	STATUS		
-----+-----+-----+-----+-----+-----+-----						
81	cafe:1:2::11	0 /PRI				
/1 ce4	fe80::3e2c:99ff:fec9:9ac	cafe:1:2:a11:3::		Active	0x2000ccda	
80	cafe:1:2::11	0 /PRI				
/1 ce4	fe80::3e2c:99ff:fec9:9ac	cafe:1:2:a11:2::		Active	0x2000ccd8	

PE2#show hsl srv6 evpn 80

TABLE: SRV6 EVPN Table

-----+-----+-----+-----+-----+-----+-----						
-----+-----+-----+-----+-----+-----+-----						
EVPN SEGMENT	DESTINATION CACHE	POLICY-ID/ FEC_ID	OUT	NEXTHOP	EVPN	
ID	FEC	TYPE/NHLFE-ID	IFNAME	STATUS		
-----+-----+-----+-----+-----+-----+-----						
80	cafe:1:2::11	0	/PRI			
/1	ce4	fe80::3e2c:99ff:fec9:9ac	cafe:1:2:a11:2::	Active	0x2000ccd8	

PE2#show hsl srv6 evpn 81

TABLE: SRV6 EVPN Table

-----+-----+-----+-----+-----+-----+-----						
-----+-----+-----+-----+-----+-----+-----						
EVPN	DESTINATION	POLICY-ID/	OUT	NEXTHOP	EVPN	
SEGMENT	CACHE	FEC_ID				
ID	FEC	TYPE/NHLFE-ID	IFNAME	STATUS		
-----+-----+-----+-----+-----+-----+-----						
81	cafe:1:2::11	0	/PRI			
/1	ce4	fe80::3e2c:99ff:fec9:9ac	cafe:1:2:a11:3::	Active	0x2000ccda	

PE2#show evpn srv6 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				
=====							
80	eline-sh1	1500	70	ce6.100	---	Single Homed Port ---	
	cafe:1:2::11	1500	AC-NW	NW-SET			
81	eline-sh2	1500	71	ce6.101	---	Single Homed Port ---	
	cafe:1:2::11	1500	AC-NW	NW-SET			

Total number of entries are 2

PE2#show evpn srv6 xconnect id 80

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				
80	eline-sh1	1500	70	ce6.100	---	Single Homed Port ---	
	cafe:1:2::11	1500	AC-NW	NW-SET			

Total number of entries are 1

```
PE2#show evpn srv6 xconnect id 81
```

```
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				
81	eline-sh2	1500	71	ce6.101	---	Single Homed Port ---	
	cafe:1:2::11	1500	AC-NW	NW-SET			

Total number of entries are 1

```
PE2#show evpn srv6 xconnect tunnel summary
```

```
Total number of entries: 2 [Installed: 2, Resolved: 0, Unresolved: 0]
```

```
PE2#show evpn srv6 xconnect tunnel sid
```

```
EVPN-SRV6 Network tunnel SID's
```

```
Evpn service type: ELINE
```

```
EVI-NAME: NA
```

```
PE IP: cafe:1:2::11
```

```
Status: Installed
```

```
Xconnect information
```

```
Local Ethernet Tag Id: 81
```

```
Local UC-SID: cafe:1:2:a22:3::
```

```
Remote Ethernet Tag Id: 71
```

```
Remote UC-SID: cafe:1:2:a11:3::
```

```
Tunnel policy mapped: --
```

```
Evpn service type: ELINE
```

```
EVI-NAME: NA
```

```
PE IP: cafe:1:2::11
```

```
Status: Installed
```

```
Xconnect information
```

```
Local Ethernet Tag Id: 80
```

```
Local UC-SID: cafe:1:2:a22:2::
```

```
Remote Ethernet Tag Id: 70
```

```
Remote UC-SID: cafe:1:2:a11:2::
```

```
Tunnel policy mapped: --
```

Total number of entries are 2

SRV6 EVPN ELINE SH Configuration with Policy



Notes:

- This section is continuation of SRV6 EVPN ELINE SH Configuratio without Policy section.
- If Traffic engineering needed, SR-Policy can be used otherwise not needed.

SRv6 Policy Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1 (config) #tunnel-policy policy0	Configure tunnel policy0
PE1 (config-tnl-policy) #color 1	Color to be used as 1
PE1 (config-tnl-policy) #exit	Exit to config mode
PE1 (config) #tunnel-policy policy1	Configure tunnel policy1
PE1 (config-tnl-policy) #color 2	Color to be used as 2
PE1 (config-tnl-policy) #exit	Exit to config mode
PE1 (config) #mac vrf vrf3	Enter into mac vrf3
PE1 (config-vrf) #tunnel-select-policy policy0	Tunnel-policy to be mapped as policy0
PE1 (config-vrf) #exit	Exit to config mode
PE1 (config) #mac vrf vrf4	Enter into mac vrf4
PE1 (config-vrf) #tunnel-select-policy policy1	Tunnel-policy to be mapped as policy1
PE1 (config-vrf) #exit	Exit to config mode
PE1 (config) #segment-routing	Enter into segment-routing
PE1 (config-sr) #traffic-engineering	Segment Routing traffic engineering
PE1 (config-sr-te) #segment-list 2	Configure segment list as 2
PE1 (config-sr-sl) #index 1 segment-type-2 cafe:1:2:a22:2002::	Configure segment type 2 with SRv6 SIDs
PE1 (config-sr-sl) #exit-sr-sl	Exit segment list mode
PE1 (config-sr-te) #segment-list 1	Configure segment list as 1
PE1 (config-sr-sl) #index 1 segment-type-2 cafe:1:2:a22:2001::	Configure segment type 2 with SRv6 SIDs

PE1 (config-sr-sl) #exit-sr-sl	Exit segment list mode
PE1 (config-sr-te) #policy 2	Policy configuration with name 2
PE1 (config-sr-pol) #color 2 end-point cafe:1:2::22	SR-policy color and end-point
PE1 (config-sr-pol) #candidate-path 2	SR policy candidate path
PE1 (config-sr-pol-cp) #preference 100	Configure Preference
PE1 (config-sr-pol-cp) #explicit segment- list 2	configure a candidate path as an explicit path and attach a segment-list to it
PE1 (config-sr-pol-cp) #exit-pol-cp	Exit candidate path
PE1 (config-sr-pol) #exit-sr-pol	Exit from SR policy configuration mode
PE1 (config-sr-te) #policy 1	Policy configuration with name 1
PE1 (config-sr-pol) #color 1 end-point cafe:1:2::22	SR-policy color and end-point
PE1 (config-sr-pol) #candidate-path 1	SR policy candidate path
PE1 (config-sr-pol-cp) #preference 100	Configure Preference
PE1 (config-sr-pol-cp) #explicit segment- list 1	configure a candidate path as an explicit path and attach a segment-list to it
PE1 (config-sr-pol-cp) #exit-pol-cp	Exit candidate path
PE1 (config-sr-pol) #exit-sr-pol	Exit from SR policy configuration mode
PE1 (config-sr-te) #exit-te	Exit from traffic engineering configuration mode
PE1 (config-sr) #exit	Exit segment routing

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode
PE2 (config) #tunnel-policy policy0	Configure tunnel policy0
PE2 (config-tnl-policy) # color 1	Color to be used as 1
PE2 (config-tnl-policy) #exit	Exit to config mode
PE2 (config) #tunnel-policy policy1	Configure tunnel policy1
PE2 (config-tnl-policy) # color 2	Color to be used as 2
PE2 (config-tnl-policy) #exit	Exit to config mode
PE2 (config) #mac vrf vrf3	Enter into mac vrf3
PE2 (config-vrf) # tunnel-select-policy policy0	Tunnel-policy to be mapped as policy0

PE2 (config-vrf) #exit	Exit to config mode
PE2 (config) #mac vrf vrf4	Enter into mac vrf4
PE2 (config-vrf) #tunnel-select-policy policy1	Tunnel-policy to be mapped as policy1
PE2 (config-vrf) #exit	Exit to config mode
PE2 (config) #segment-routing	Enter into segment-routing
PE2 (config-sr) #traffic-engineering	Segment Routing traffic engineering
PE2 (config-sr-te) #segment-list 2	Configure segment list as 2
PE2 (config-sr-sl) #index 1 segment-type-2 cafe:1:2:a11:2002::	Configure segment type 2 with SRv6 SIDs
PE2 (config-sr-sl) #exit-sr-sl	Exit segment list mode
PE2 (config-sr-te) #segment-list 1	Configure segment list as 1
PE2 (config-sr-sl) #index 1 segment-type-2 cafe:1:2:a11:2001::	Configure segment type 2 with SRv6 SIDs
PE2 (config-sr-sl) #exit-sr-sl	Exit segment list mode
PE2 (config-sr-te) #policy 2	Policy configuration with name 2
PE2 (config-sr-pol) #color 2 end-point cafe:1:2::11	SR-policy color and end-point
PE2 (config-sr-pol) #candidate-path 2	SR policy candidate path
PE2 (config-sr-pol-cp) #preference 100	Configure Preference
PE2 (config-sr-pol-cp) #explicit segment-list 2	configure a candidate path as an explicit path and attach a segment-list to it
PE2 (config-sr-pol-cp) #exit-pol-cp	Exit candidate path
PE2 (config-sr-pol) #exit-sr-pol	Exit from SR policy configuration mode
PE2 (config-sr-te) #policy 1	Policy configuration with name 1
PE2 (config-sr-pol) #color 1 end-point cafe:1:2::11	SR-policy color and end-point
PE2 (config-sr-pol) #candidate-path 1	SR policy candidate path
PE2 (config-sr-pol-cp) #preference 100	Configure Preference
PE2 (config-sr-pol-cp) #explicit segment-list 1	configure a candidate path as an explicit path and attach a segment-list to it
PE2 (config-sr-pol-cp) #exit-pol-cp	Exit candidate path
PE2 (config-sr-pol) #exit-sr-pol	Exit from SR policy configuration mode
PE2 (config-sr-te) #exit-te	Exit from traffic engineering configuration mode
PE2 (config-sr) #exit	Exit segment routing

Validation

Validation for SRV6 EVPN ELINE SH with Tunnel Policy

SR Tunnel Policy Validation

```
PE1#show segment-routing policy
```

Policy-Name	State	Forwarding-Info	Color	End-	
point					
2			2	cafe:1:2::22	UP
	cafe:1:2:a22:2002::/ce16				
1			1	cafe:1:2::22	UP
	cafe:1:2:a22:2001::/ce16				

```
PE1#show segment-routing policy detail
```

```
Policy-Name: 2      Color 2      End-point cafe:1:2::22      Tunnel-ID: 2
Admin-Status: UP    Oper-Status: UP for 00:11:18
State Transition Count: 1
CP ID: 2, Active
  Preference: 100    Path Type: Explicit    CP Origin: Local
  CP state: Valid
  Segment List:
  Total no. of segments: 1
    Segment0[SRv6]: SID :cafe:1:2:a22:2002::
  Out-if: ce16      Out-label-stack: cafe:1:2:a22:2002::
  Attributes:
    Configured:
      Explicit segment-list Name: 2
```

```
Policy-Name: 1      Color 1      End-point cafe:1:2::22      Tunnel-ID: 1
Admin-Status: UP    Oper-Status: UP for 00:18:21
State Transition Count: 1
CP ID: 1, Active
  Preference: 100    Path Type: Explicit    CP Origin: Local
  CP state: Valid
  Segment List:
  Total no. of segments: 1
    Segment0[SRv6]: SID :cafe:1:2:a22:2001::
  Out-if: ce16      Out-label-stack: cafe:1:2:a22:2001::
  Attributes:
    Configured:
      Explicit segment-list Name: 1
```

```
PE2#show segment-routing policy
```

Policy-Name	State	Forwarding-Info	Color	End-	
point					
2			2	cafe:1:2::11	UP
	cafe:1:2:a11:2002::/ce4				
1			1	cafe:1:2::11	UP
	cafe:1:2:a11:2001::/ce4				

```
PE2#show segment-routing policy detail
```

```
Policy-Name: 2      Color 2      End-point cafe:1:2::11      Tunnel-ID: 2
Admin-Status: UP    Oper-Status: UP for 00:09:53
State Transition Count: 1
CP ID: 2, Active
  Preference: 100    Path Type: Explicit    CP Origin: Local
  CP state: Valid
  Segment List:
  Total no. of segments: 1
    Segment0[SRv6]: SID :cafe:1:2:a11:2002::
  Out-if: ce4      Out-label-stack: cafe:1:2:a11:2002::
  Attributes:
```

```

Configured:
  Explicit segment-list Name: 2

Policy-Name: 1    Color 1    End-point cafe:1:2::11    Tunnel-ID: 1
Admin-Status: UP    Oper-Status: UP for 00:18:10
State Transition Count: 1
CP ID: 1, Active
  Preference: 100    Path Type: Explicit    CP Origin: Local
  CP state: Valid
  Segment List:
  Total no. of segments: 1
  Segment0[SRv6]: SID :cafe:1:2:a11:2001::
  Out-if: ce4    Out-label-stack: cafe:1:2:a11:2001::
  Attributes:
  Configured:
    Explicit segment-list Name: 1

```

SRv6 EVPN ELINE SH with Policy Validation

```

PE1#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:

EVPN:
Service Flags vrf          local-evpn-id  remote-evpn-
id      SID              Nexthop
ELINE   >T      vrf3      70              80          SRv6-Policy-Name
22              1              cafe:1:2:a22:2::      cafe:1:2::
ELINE   >T      vrf4      71              81          cafe:1:2:a22:3::      cafe:1:2::
22              2

PE2#show segment-routing policy

Policy-Name                Color      End-
point      State      Forwarding-Info
2              cafe:1:2:a11:2002::/ce4      2      cafe:1:2::11      UP
1              cafe:1:2:a11:2001::/ce4      1      cafe:1:2::11      UP

PE1#show segment-routing srv6 services evpn
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf          local-evpn-id  remote-evpn-
id      SID              Nexthop
ELINE   >T      vrf3      70              80          SRv6-Policy-Name
22              1              cafe:1:2:a22:2::      cafe:1:2::
ELINE   >T      vrf4      71              81          cafe:1:2:a22:3::      cafe:1:2::
22              2

PE1#show segment-routing srv6 sid
SRv6 Segment ID table:
SID              Operation      Nexthop              Originator
+-----+-----+-----+-----+
cafe:1:2:a11:2::  END.DX2      ::                  evpn:70
cafe:1:2:a11:3::  END.DX2      ::                  evpn:71
cafe:1:2:a11:801::  END[usd]     ::                  nsm
cafe:1:2:a11:1001::  END[usp]     ::                  nsm
cafe:1:2:a11:2001::  END[psp]     ::                  nsm
cafe:1:2:a11:6001::  END.X[psp]   fe80::3e2c:99ff:fec9:9ad isis

PE1#show hsl srv6 evpn
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS |
|

```

```

+-----+-----+-----+-----+-----+-----+-----+-----+
+-----+-----+-----+-----+-----+-----+-----+-----+
  71    cafe:1:2::22      2 /PRI
/5    ce16  fe80::3e2c:99ff:fec9:9ad  cafe:1:2:a22:3::      Active  0x2000ccdf
  70    cafe:1:2::22      1 /PRI
/2    ce16  fe80::3e2c:99ff:fec9:9ad  cafe:1:2:a22:2::      Active  0x2000ccdd

PE1#show hsl srv6 evpn 70
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+-----+
+-----+-----+-----+-----+-----+-----+-----+-----+
| EVPN |      DESTINATION      | POLICY-ID/ | OUT |      NEXTHOP      |      EVPN |
SEGMENT |  CACHE  |  FEC_ID  |      |      |      |      |
| ID |      FEC      | TYPE/NHLFE-ID | IFNAME |      | STATUS |      |
+-----+-----+-----+-----+-----+-----+-----+-----+
+-----+-----+-----+-----+-----+-----+-----+-----+
  70    cafe:1:2::22      1 /PRI
/2    ce16  fe80::3e2c:99ff:fec9:9ad  cafe:1:2:a22:2::      Active  0x2000ccdd

PE1#show hsl srv6 evpn 71
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+-----+
+-----+-----+-----+-----+-----+-----+-----+-----+
| EVPN |      DESTINATION      | POLICY-ID/ | OUT |      NEXTHOP      |      EVPN |
SEGMENT |  CACHE  |  FEC_ID  |      |      |      |      |
| ID |      FEC      | TYPE/NHLFE-ID | IFNAME |      | STATUS |      |
+-----+-----+-----+-----+-----+-----+-----+-----+
+-----+-----+-----+-----+-----+-----+-----+-----+
  71    cafe:1:2::22      2 /PRI
/5    ce16  fe80::3e2c:99ff:fec9:9ad  cafe:1:2:a22:3::      Active  0x2000ccdf

PE1#show evpn srv6 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
=====
70          eline-sh1     1500  80          ce15.100    --- Single Homed Port ---
      cafe:1:2::22  1500  AC-NW  NW-SET
71          eline-sh2     1500  81          ce15.101    --- Single Homed Port ---
      cafe:1:2::22  1500  AC-NW  NW-SET

Total number of entries are 2

PE1#show evpn srv6 xconnect id 70
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
=====
70          eline-sh1      1500  80          ce15.100    --- Single Homed Port ---
          cafe:1:2::22    1500  AC-NW  NW-SET

Total number of entries are 1

PE1#show evpn srv6 xconnect id 71
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
=====
71          eline-sh2      1500  81          ce15.101    --- Single Homed Port ---
          cafe:1:2::22    1500  AC-NW  NW-SET

Total number of entries are 1

PE1#show evpn srv6 xconnect tunnel summary

Total number of entries: 2 [Installed: 2, Resolved: 0, Unresolved: 0]

PE1#show evpn srv6 xconnect tunnel sid
EVPN-SRV6 Network tunnel SID's
Evpn service type: ELINE
EVI-NAME: NA
PE IP: cafe:1:2::22
Status: Installed
Xconnect information
Local Ethernet Tag Id: 70
Local UC-SID: cafe:1:2:a11:2::
Remote Ethernet Tag Id: 80
Remote UC-SID: cafe:1:2:a22:2::
Tunnel policy mapped: policy0
Evpn service type: ELINE
EVI-NAME: NA
PE IP: cafe:1:2::22
Status: Installed
Xconnect information
Local Ethernet Tag Id: 71
Local UC-SID: cafe:1:2:a11:3::
Remote Ethernet Tag Id: 81
Remote UC-SID: cafe:1:2:a22:3::
Tunnel policy mapped: policy1

Total number of entries are 2

PE2#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:

EVPN:
Service Flags vrf          local-evpn-id  remote-evpn-
id    SID              Nexthop
ELINE  >T    vrf3          80          70          SRv6-Policy-Name
                                cafe:1:2:a11:2::    cafe:1:2::

```

```

11          1
ELINE >T    vrf4      81          71          cafe:1:2:a11:3::      cafe:1:2::
11          2

PE2#show segment-routing srv6 services evpn
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID            Nexthop
ELINE >T    vrf3      80          70          SRv6-Policy-Name
11          1          cafe:1:2:a11:2::      cafe:1:2::
ELINE >T    vrf4      81          71          cafe:1:2:a11:3::      cafe:1:2::
11          2

PE2#show segment-routing srv6 sid
SRv6 Segment ID table:
SID            Operation      Nexthop            Originator
+-----+-----+-----+-----+
cafe:1:2:a22:2::  END.DX2      ::                evpn:80
cafe:1:2:a22:3::  END.DX2      ::                evpn:81
cafe:1:2:a22:801:: END[usd]     ::                nsm
cafe:1:2:a22:1001:: END[usp]     ::                nsm
cafe:1:2:a22:2001:: END[psp]     ::                nsm
cafe:1:2:a22:6001:: END.X[psp]   fe80::3e2c:99ff:fec9:9ac isis

PE2#show hsl srv6 evpn
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+
81      cafe:1:2::11      2 /PRI
/3      ce4      fe80::3e2c:99ff:fec9:9ac      cafe:1:2:a11:3::      Active      0x2000ccda
80      cafe:1:2::11      1 /PRI
/2      ce4      fe80::3e2c:99ff:fec9:9ac      cafe:1:2:a11:2::      Active      0x2000ccd8

PE2#show hsl srv6 evpn 80
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+
80      cafe:1:2::11      1 /PRI
/2      ce4      fe80::3e2c:99ff:fec9:9ac      cafe:1:2:a11:2::      Active      0x2000ccd8

PE2#show hsl srv6 evpn 81
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+
81      cafe:1:2::11      2 /PRI
/3      ce4      fe80::3e2c:99ff:fec9:9ac      cafe:1:2:a11:3::      Active      0x2000ccda

PE2#show evpn srv6 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
=====
80           eline-sh1     1500  70          ce6.100     --- Single Homed Port ---
      cafe:1:2::11    1500  AC-NW  NW-SET
81           eline-sh2     1500  71          ce6.101     --- Single Homed Port ---
      cafe:1:2::11    1500  AC-NW  NW-SET

Total number of entries are 2

PE2#show evpn srv6 xconnect tunnel summary

Total number of entries: 2 [Installed: 2, Resolved: 0, Unresolved: 0]

PE2#show evpn srv6 xconnect tunnel sid
EVPN-SRV6 Network tunnel SID's
Evpn service type: ELINE
  EVI-NAME: NA
  PE IP: cafe:1:2::11
  Status: Installed
Xconnect information
  Local Ethernet Tag Id: 80
  Local UC-SID: cafe:1:2:a22:2::
  Remote Ethernet Tag Id: 70
  Remote UC-SID: cafe:1:2:a11:2::
  Tunnel policy mapped: policy0
Evpn service type: ELINE
  EVI-NAME: NA
  PE IP: cafe:1:2::11
  Status: Installed
Xconnect information
  Local Ethernet Tag Id: 81
  Local UC-SID: cafe:1:2:a22:3::
  Remote Ethernet Tag Id: 71
  Remote UC-SID: cafe:1:2:a11:3::
  Tunnel policy mapped: policy1

Total number of entries are 2

```

SRv6 EVPN ELINE Multi-Homing

- Traditional legacy VPLS does not have a solution for all active Multi-Homing. There is a partial solution for single active Multi-Homing. EVPN removes this limitation. EVPN has a standardized solution for both all-active and single-active Multi-Homing (currently only all-active support is provided).
- Ethernet Segment Identifier (ESI) is configured in Multi-Homed PE's interfaces which are connected to a single CE. For Particular ESI, multi-homed PE does the designated forwarder (DF) election to select which PE shall be responsible for sending BUM traffic towards CE. non-DF blocks the BUM traffic towards CE thus avoiding duplicate BUM traffic.
- Unicast Traffic (traffic towards known destination MAC/IP) is load shared towards both Multi-Homed PEs and further towards CE.

- ESI configuration at PE generates below two EVPN route types.
- When a multihomed CE is configured as an attachment circuit, the Ethernet Segment Route is sent. The main purpose of this route is to discover other PEs which share the ES and to perform DF elections, Fast convergence, and Split Horizon.
- Another Route sent by PE, when a CE is multi-homed, is the Ethernet A-D Route per EVI. This is used to announce a label (unicast/alias label) that can be used for load sharing by the remote PEs.
- ESI value is carried in the BGP NLRI prefix for Ethernet A-D routes. Ethernet A-D per ES route is responsible for mass withdrawal. It withdraws the instantiation of all VPWS point-to-point instances within the same ESI.
- The bit flag is set to "1" in the ESI Label extended community advertised with Ethernet A-D per ES route for single-active. It is set as "0" in All-active mode. Currently, OcNOS supports only All-Active mode.

Operational Notes for EVPN VPWS:

- Ethernet A-D routes are used for peer auto-discovery. Inclusive Multicast Route is not required or does not have participation in auto-discovery.
- ARP/ND uplift functionality is not applicable for VPWS.
- MAC/MAC-IP routes advertisement/learning is not applicable for VPWS.
- In multi-Homing VPWS, as there is no BUM traffic concept and only ALL-ACTIVE mode supported DF/non-DF election, and Split-Horizon concept is not applicable.
- MTU should be matching the VPWS peer's attachment circuits.
- Unlike E-LAN-EVPN, in all service types, the EVPN routes carry the Ethernet Tag Id as VPWS identifier.

Topology

Below example shows the SRv6 EVPN ELINE Multi-Homing configurations:

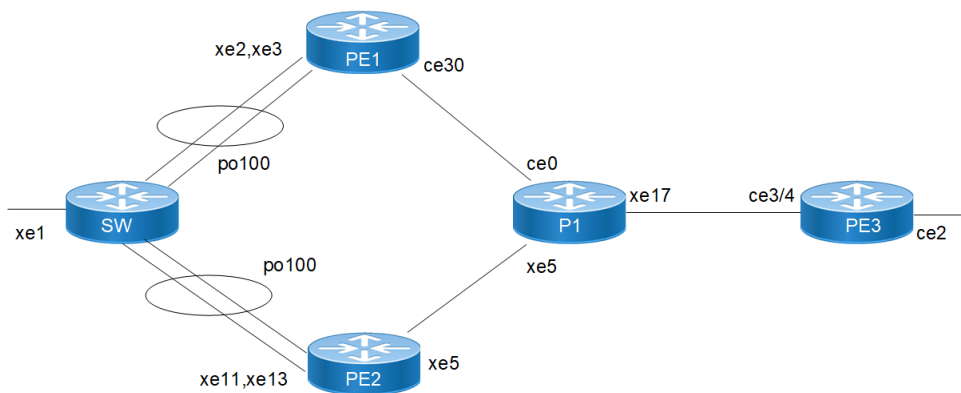


Figure 35. SRv6 EVPN ELINE Multi-Homing Topology**SRV6 EVPN ELINE MH Configuration****SW****Interface Configurations**

SW(config)#interface po100	Creating po100 lag interface
SW(config-if)#switchport	Configuring lag interface as L2 switch port
SW(config)#interface po100.3 switchport	Creating L2 sub interface of lag interface po100
SW(config-if)#encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
SW(config)#interface xe1	Configuring physical interface xe1
SW(config-if)#switchport	Configuring physical interface as L2 switch port
SW(config)#interface xe1.3 switchport	Creating L2 sub interface of physical interface xe1
SW(config-if)#encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100
SW(config)#interface xe2	Configuring physical interface xe2
SW(config-if)# channel-group 100 mode active	Attaching to channel group 100 as active mode
SW(config)#interface xe3	Configuring physical interface xe3
SW(config-if)# channel-group 100 mode active	Attaching to channel group 100 as active mode
SW(config)#interface xe11	Configuring physical interface xe11
SW(config-if)# channel-group 100 mode active	Attaching to channel group 100 as active mode
SW(config)#interface xe13	Configuring physical interface xe13
SW(config-if)# channel-group 100 mode active	Attaching to channel group 100 as active mode
SW(config)#exit	Exit interface mode
SW(config-if)#cross-connect xe1_po100_3	Configuring cross connect
SW(config-xc)#interface xe1.3	Attaching interface xe1.3 to cross connect
SW(config-xc)#interface po100.3	Attaching interface po100.3 to cross connect
SW(config)#exit	Exit cross connect config mode

PE1**Loopback Interface**

PE1#configure terminal	Enter configure mode.
------------------------	-----------------------

PE1(config)#interface lo	Enter interface mode.
PE1(config-if)#ipv6 address 1001::1/128	Configure IPv6 address of the loopback interface.
PE1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#exit	Exit interface mode.

Global SRv6 EVPN Command

PE1#configure terminal	Enter configure mode.
PE1(config)#evpn srv6 enable	Enable srv6 evpn under config mode
PE1(config)#evpn srv6 multihoming enable	Enable srv6 evpn multi homing under config mode
PE1(config)#evpn srv6 ip-global 1001::1	Configuring SRv6 global IP to loopback IP
PE1(config)#qos enable	Enable qos

Interface Configuration Network Side

PE1(config)#interface ce30	Enter interface mode.
PE1(config-if)#ipv6 address 1112::1/64	Configure the IPv6 address of the interface.
PE1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#exit	Exit the interface

ISIS Configuration

PE1(config)#router isis 1	Set the routing process ID as 1
PE1(config-router)#is-type level-2-only	Configure isis level2
PE1(config-router)#metric-style wide	Configure wide metric-style
PE1(config-router)#net 49.0001.0000.0000.0001.00	Configure Network entity title (NET).
PE1(config-router)#address-family ipv6	Enter Address-family IPv6
PE1(config-router-af)#segment-routing srv6	Enter into segment routing SRv6 mode
PE1(config-router-af-srv6)#srv6-locator PE1_locator	Configure SRv6 locator name
PE1(config-router-af-srv6)#exit-srv6	Exit SRv6 mode

PE1(config-router-af)#exit	Exit address family mode
PE1(config-router)#exit	Exit router mode.

BGP Configuration

PE1(config)#router bgp 100	Configure router BGP in AS 100
PE1(config-router)#bgp router-id 1.1.1.1	Configure BGP Router ID
PE1(config-router)#neighbor 2001::1 remote-as 100	Configure neighbor remote-as 100
PE1(config-router)#neighbor 2001::1 update-source lo	Configure neighbor with update-source lo
PE1(config-router)#neighbor 3001::1 remote-as 100	Configure neighbor remote-as 100
PE1(config-router)#neighbor 3001::1 update-source lo	Configure neighbor with update-source lo
PE1(config-router)#address-family l2vpn evpn	Configure address-family l2vpn evpn
PE1(config-router-af)#neighbor 2001::1 activate	Activate neighbor under l2vpn evpn address family
PE1(config-router-af)#neighbor 3001::1 activate	Activate neighbor under l2vpn evpn address family
PE1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE1(config-router)#exit	Exit router prompt

MAC VRF Configuration

PE1#configure terminal	Enter configure mode.
PE1(config)#mac vrf ELINE_MH	Configure mac VRF with name ELINE_MH
PE1(config-vrf)#rd 10:10	Configure Route-distinguisher value
PE1(config-vrf)#route-target both 10:10	Configure Route target value
PE1(config-vrf)#exit	Exit to config mode

EVPN and MAC VRF Mapping

PE1#configure terminal	Enter into config mode
PE1(config)#evpn srv6 id 12 xconnect target-srv6-id 42	Configure the EVPN-ELINE identifier with source identifier 12 and target identifier 42

PE1(config-evpn-srv6)#host-reachability-protocol evpn-bgp ELINE_MH	Configure host reachable protocol to Ethernet-VPN over BGP
PE1(config-evpn-srv6)#locator PE1_locator	Configure Locator Name
PE1(config-evpn-srv6)#exit	Exit evpn srv6
PE1(config)#interface po100	Creating po100 lag interface
PE1(config-if)#switchport	Configuring lag interface as L2 switch port
PE1(config-if)#evpn multi-homed system-mac 0000.1111.1111	Configuring evpn multi-homed system-mac
PE1(config)#interface xe2	Configuring physical interface xe2
PE1(config-if)# channel-group 100 mode active	Attaching to channel group 100 as active mode
PE1(config)#interface xe3	Configuring physical interface xe3
PE1(config-if)# channel-group 100 mode active	Attaching to channel group 100 as active mode
PE1(config)#exit	Exit interface mode
PE1(config)#interface po100.3 switchport	Creating L2 sub interface of physical interface po100
PE1(config-if)#encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100 Supported Encapsulation: dot1ad, dot1q, untagged, default
PE1(config-if)#access-if-evpn	Create the evpn mpls access-port
PE1(config-acc-if-evpn)#map vpn-id 12	Map vpn-id 12 to interface
PE1(config-acc-if-evpn)#exit	Exit evpn mapping mode
PE1(config-if)#exit	Exit evpn access mode

SRv6 Segment Routing

PE1(config)#segment-routing	Configuring segment-routing
PE1(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
PE1(config-srv6)#locators	Configure SRv6 locators
PE1(config-srv6-loc)#locator PE1_locator	Locator name as PE1_locator
PE1(config-srv6-loc-conf)#prefix 1001::/64	IPv6 prefix for locator
PE1(config-srv6-loc-conf)#exit-locator	Exit from locator mode
PE1(config-srv6-loc)#exit-locators	Exit from SRv6 locators configuration mode

PE1 (config-srv6) #exit-srv6	Exit from SRv6 configuration mode
PE1 (config-sr) #exit	Exit segment routing

PE2**Loopback Interface**

PE2#configure terminal	Enter configure mode.
PE2 (config) #interface lo	Enter interface mode.
PE2 (config-if) #ipv6 address 2001::1/128	Configure IPv6 address of the loopback interface.
PE2 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE2 (config-if) #exit	Exit interface mode.

Global SRv6 EVPN Command

PE2#configure terminal	Enter configure mode.
PE2 (config) #evpn srv6 enable	Enable srv6 evpn under config mode
PE2 (config) #evpn srv6 multihoming enable	Enable srv6 evpn multi homing under config mode
PE2 (config) #evpn srv6 ip-global 2001::1	Configuring SRv6 global IP to loopback IP
PE2 (config) #qos enable	Enable qos

Interface Configuration Network Side

PE2 (config) #interface xe5	Enter interface mode.
PE2 (config-if) #ipv6 address 2222::1/64	Configure the IPv6 address of the interface.
PE2 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE2 (config-if) #exit	Exit the interface

ISIS Configuration

PE2 (config) #router isis 1	Set the routing process ID as 1
PE2 (config-router) #is-type level-2-only	Configure isis level2
PE2 (config-router) #metric-style wide	Configure wide metric-style
PE2 (config-router) #net	Configure Network entity title (NET).

49.0002.0000.0000.0002.00	
PE2(config-router)#address-family ipv6	Enter Address-family IPv6
PE2(config-router-af)#segment-routing srv6	Enter into segment routing SRv6 mode
PE2(config-router-af-srv6)#srv6-locator PE1_locator	Configure SRv6 locator name
PE2(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE2(config-router-af)#exit	Exit address family mode
PE2(config-router)#exit	Exit router mode.

BGP Configuration

PE2(config)#router bgp 100	Configure router BGP in AS 100
PE2(config-router)#bgp router-id 2.2.2.2	Configure BGP Router ID
PE2(config-router)#neighbor 1001::1 remote-as 100	Configure neighbor remote-as 100
PE2(config-router)#neighbor 1001::1 update-source lo	Configure neighbor with update-source lo
PE2(config-router)#neighbor 3001::1 remote-as 100	Configure neighbor remote-as 100
PE2(config-router)#neighbor 3001::1 update-source lo	Configure neighbor with update-source lo
PE2(config-router)#address-family l2vpn evpn	Configure address-family l2vpn evpn
PE2(config-router-af)#neighbor 1001::1 activate	Activate neighbor under l2vpn evpn address family
PE2(config-router-af)#neighbor 3001::1 activate	Activate neighbor under l2vpn evpn address family
PE2(config-router-af)#exit-address-family	Exit from Address Family configuration mode
PE2(config-router)#exit	Exit router prompt

MAC VRF Configuration

PE2#configure terminal	Enter configure mode.
PE2(config)#mac vrf ELINE_MH	Configure mac VRF with name ELINE_MH
PE2(config-vrf)#rd 20:20	Configure Route-distinguisher value
PE2(config-vrf)#route-target both 10:10	Configure Route target value

PE2 (config-vrf) #exit	Exit to config mode
------------------------	---------------------

EVPN and MAC VRF Mapping

PE2#configure terminal	Enter into config mode
PE2 (config) #evpn srv6 id 12 xconnect target-srv6-id 42	Configure the EVPN-ELINE identifier with source identifier 12 and target identifier 42
PE2 (config-evpn-srv6) #host-reachability-protocol evpn-bgp ELINE_MH	Configure host reachable protocol to Ethernet-VPN over BGP
PE2 (config-evpn-srv6) #locator PE1_locator	Configure Locator Name
PE2 (config-evpn-srv6) #exit	Exit evpn srv6
PE2 (config) #interface po100	Creating po100 lag interface
PE2 (config-if) #switchport	Configuring lag interface as L2 switch port
PE2 (config-if) #evpn multi-homed system-mac 0000.1111.1111	Configuring evpn multi-homed system-mac
PE2 (config) #interface xe11	Configuring physical interface xe11
PE2 (config-if) # channel-group 100 mode active	Attaching to channel group 100 as active mode
PE2 (config) #interface xe13	Configuring physical interface xe13
PE2 (config-if) # channel-group 100 mode active	Attaching to channel group 100 as active mode
PE2 (config) #exit	Exit interface mode
PE2 (config) #interface po100.3 switchport	Creating L2 sub interface of physical interface po100
PE2 (config-if) #encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100 Supported Encapsulation: dot1ad, dot1q, untagged, default
PE2 (config-if) #access-if-evpn	Create the evpn mpls access-port
PE2 (config-acc-if-evpn) #map vpn-id 12	Map vpn-id 12 to interface
PE2 (config-acc-if-evpn) #exit	Exit evpn mapping mode
PE2 (config-if) #exit	Exit evpn access mode

SRv6 Segment Routing

PE2 (config) #segment-routing	Configuring segment-routing
PE2 (config-sr) #srv6	Segment-Routing over IPv6 Data-Plane

PE2 (config-srv6) #locators	Configure SRv6 locators
PE2 (config-srv6-loc) #locator PE1_ locator	Locator name as PE1_locator
PE2 (config-srv6-loc-conf) #prefix 2001::/64	IPv6 prefix for locator
PE2 (config-srv6-loc-conf) #exit-locator	Exit from locator mode
PE2 (config-srv6-loc) #exit-locators	Exit from SRv6 locators configuration mode
PE2 (config-srv6) #exit-srv6	Exit from SRv6 configuration mode
PE2 (config-sr) #exit	Exit segment routing

P1**Interface Configuration**

P1#configure terminal	Enter configure mode.
P1 (config) #interface ce0	Enter interface mode.
P1 (config-if) #ipv6 address 1112::2/64	Configure the IPv6 address of the interface.
P1 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS 1 instance
P1 (config-if) #interface xe5	Enter interface mode.
P1 (config-if) #ipv6 address 2222::2/64	Configure the IP address of the interface.
P1 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P1 (config-if) #interface xe17	Enter interface mode.
P1 (config-if) #ipv6 address 3332::2/64	Configure the IP address of the interface.
P1 (config-if) #ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P1 (config-if) #exit	Exit interface mode.

ISIS Configuration

P1#configure terminal	Enter configure mode.
P1 (config) #router isis 1	Set the routing process ID as 1
P1 (config-router) #is-type level-2-only	Configure is-type as level-2
P1 (config-router) #metric-style wide	Configure wide metric-style
P1 (config-router) #net 49.0006.0000.0000.0006.00	Configure Network entity title (NET).

P1(config-router)#address-family ipv6	Enter Address-family IPv6
P1(config-router-af)#exit-address-family	Exit address family IPv6
P1(config-router)#exit	Exit router mode.

PE3**Loopback Interface**

PE3#configure terminal	Enter configure mode.
PE3(config)#interface lo	Enter interface mode.
PE3(config-if)#ipv6 address 3001::1/128	Configure IPv6 address of the loopback interface.
PE3(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE3(config-if)#exit	Exit interface mode.

Global SRv6 EVPN Command

PE3#configure terminal	Enter configure mode.
PE3(config)#evpn srv6 enable	Enable srv6 evpn under config mode
PE3(config)#evpn srv6 multihoming enable	Enable srv6 evpn multi homing under config mode
PE3(config)#evpn srv6 ip-global 3001::1	Configuring SRv6 global IP to loopback IP
PE3(config)#qos enable	Enable qos

Interface Configuration Network Side

PE3(config)#interface ce3/4	Enter interface mode.
PE3(config-if)#ipv6 address 3332::1/64	Configure the IPv6 address of the interface.
PE3(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE3(config-if)#exit	Exit the interface

ISIS Configuration

PE3(config)#router isis 1	Set the routing process ID as 1
PE3(config-router)#is-type level-2-only	Configure isis level2

PE3(config-router)#metric-style wide	Configure wide metric-style
PE2(config-router)#net 49.0003.0000.0000.0003.00	Configure Network entity title (NET).
PE3(config-router)#address-family ipv6	Enter Address-family IPv6
PE3(config-router-af)#segment-routing srv6	Enter into segment routing SRv6 mode
PE2(config-router-af-srv6)#srv6-locator PE3_locator	Configure SRv6 locator name
PE3(config-router-af-srv6)#exit-srv6	Exit SRv6 mode
PE3(config-router-af)#exit	Exit address family mode
PE3(config-router)#exit	Exit router mode.

BGP Configuration

PE3(config)#router bgp 100	Configure router BGP in AS 100
PE3(config-router)#bgp router-id 3.3.3.3	Configure BGP Router ID
PE3(config-router)#neighbor 1001::1 remote-as 100	Configure neighbor remote-as 100
PE3(config-router)#neighbor 1001::1 update-source lo	Configure neighbor with update-source lo
PE3(config-router)#neighbor 2001::1 remote-as 100	Configure neighbor remote-as 100
PE3(config-router)#neighbor 2001::1 update-source lo	Configure neighbor with update-source lo
PE3(config-router)#address-family l2vpn evpn	Configure address-family l2vpn evpn
PE3(config-router-af)#neighbor 1001::1 activate	Activate neighbor under l2vpn evpn address family
PE3(config-router-af)#neighbor 2001::1 activate	Activate neighbor under l2vpn evpn address family
PE3(config-router-af)#exit-address- family	Exit from Address Family configuration mode
PE3(config-router)#exit	Exit router prompt

MAC VRF Configuration

PE3#configure terminal	Enter configure mode.
PE3(config)#mac vrf ELINE_MH	Configure mac VRF with name ELINE_MH

PE3(config-vrf)#rd 30:30	Configure Route-distinguisher value
PE3(config-vrf)#route-target both 10:10	Configure Route target value
PE3(config-vrf)#exit	Exit to config mode

EVPN and MAC VRF Mapping

PE3#configure terminal	Enter into config mode
PE3(config)#evpn srv6 id 42 xconnect target-srv6-id 12	Configure the EVPN-ELINE identifier with source identifier 42 and target identifier 12
PE3(config-evpn-srv6)#host-reachability-protocol evpn-bgp ELINE_MH	Configure host reachable protocol to Ethernet-VPN over BGP
PE3(config-evpn-srv6)#locator PE3_locator	Configure Locator Name
PE3(config-evpn-srv6)#exit	Exit evpn srv6
PE3(config)#interface ce2	Configuring ce2 interface
PE3(config-if)#switchport	Configuring interface as L2 switch port
PE3(config)#interface ce2.3 switchport	Creating L2 sub interface of physical interface ce2
PE3(config-if)#encapsulation dot1q 100	Setting Encapsulation to dot1q with VLAN ID 100 Supported Encapsulation: dot1ad, dot1q, untagged, default
PE3(config-if)#access-if-evpn	Create the evpn mpls access-port
PE3(config-acc-if-evpn)#map vpn-id 42	Map vpn-id 12 to interface
PE3(config-acc-if-evpn)#exit	Exit evpn mapping mode
PE3(config-if)#exit	Exit evpn access mode

SRv6 Segment Routing

PE3(config)#segment-routing	Configuring segment-routing
PE3(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
PE3(config-srv6)#locators	Configure SRv6 locators
PE3(config-srv6-loc)#locator PE3_locator	Locator name as PE3_locator
PE3(config-srv6-loc-conf)#prefix 3001::/64	IPv6 prefix for locator
PE3(config-srv6-loc-conf)#exit-locator	Exit from locator mode
PE3(config-srv6-loc)#exit-locators	Exit from SRv6 locators configuration mode

PE3(config-srv6)#exit-srv6	Exit from SRv6 configuration mode
PE3(config-sr)#exit	Exit segment routing

SRV6 EVPN ELINE Validation

SRV6 ISIS Route Check

Validation on SRV6 ISIS Route

```

PE1#show clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface      SNPA              State  Holdtime  Type Protocol
0000.0000.0006 ce30          e8c5.7a79.573a    Up     20        L2    IS-IS
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,
      P - SRV6-POLICY,
      v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C      ::1/128 via ::, lo, 01:03:59
C      1001::1/128 via ::, lo, 01:03:59
C      1001::2:0:0:0/128, SRV6 END.DX2 SID
      via ::, lo, 01:03:54
C      1001::801:0:0:0/128, SRV6 END SID
      via ::, lo, 01:03:59
C      1001::1001:0:0:0/128, SRV6 END SID
      via ::, lo, 01:03:59
C      1001::2001:0:0:0/128, SRV6 END SID
      via ::, lo, 01:03:59
C      1001::6001:0:0:0/128, SRV6 END.X SID
      via fe80::eac5:7aff:fe79:573a, ce30, 01:03:48
C      1112::/64 via ::, ce30, 01:03:59
i L2   2001::/64 [115/21] via fe80::eac5:7aff:fe79:573a, ce30, 01:01:54
i L2   2001::1/128 [115/30] via fe80::eac5:7aff:fe79:573a, ce30, 01:01:54
i L2   2222::/64 [115/20] via fe80::eac5:7aff:fe79:573a, ce30, 01:02:44
i L2   3001::/64 [115/21] via fe80::eac5:7aff:fe79:573a, ce30, 00:43:56
i L2   3001::1/128 [115/30] via fe80::eac5:7aff:fe79:573a, ce30, 00:43:56
i L2   3332::/64 [115/20] via fe80::eac5:7aff:fe79:573a, ce30, 00:44:01
C      fe80::/64 via ::, ce50, 01:03:31
PE1#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* 0x00000008  0x9568        690           1/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: 1112::1
  Router Cap:   0.0.0.0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  SR-Algorithm:

```

```

    Algorithm: 0
    Metric: 10      IPv6 1112::/64
    Metric: 10      IPv6 1001::1/128
    Metric: 1       IPv6 1001::/64
    SRV6 Locator:   (IPV6)1001::/64
    Algorithm: 0  flags: 0  metric: 0
    END SID: 1001::2001:0:0:0  flags:0  End-point behaviour: End with PSP (2)
    END SID: 1001::1001:0:0:0  flags:0  End-point behaviour: End with USP (3)
    END SID: 1001::801:0:0:0   flags:0  End-point behaviour: End with USD (28)

IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00* 0x00000007  0x1FB7        679           0/0/0
Area Address: 49.0001
NLPID:         0x8E
IPv6 Address: 1112::1
Router Cap:    0.0.0.0
Maximum SID Depth:
  SRH maximum segments left : 4
  SRH maximum end pop : 4
  SRH maximum H.encaps : 4
  SRH maximum decapsulation sids : 4
SRV6 flags: 0
SR-Algorithm:
  Algorithm: 0
  Metric: 10      IS-Extended 0000.0000.0001.01
  Metric: 10      IPv6 1112::/64
  Metric: 10      IPv6 1001::1/128
  Metric: 1       IPv6 1001::/64
  SRV6 Locator:   (IPV6)1001::/64
  Algorithm: 0  flags: 0  metric: 0
  END SID: 1001::2001:0:0:0  flags:0  End-point behaviour: End with PSP (2)
  END SID: 1001::1001:0:0:0  flags:0  End-point behaviour: End with USP (3)
  END SID: 1001::801:0:0:0   flags:0  End-point behaviour: End with USD (28)
0000.0000.0001.01-00* 0x00000005  0xD9E8        676           0/0/0
  Metric: 0      IS-Extended 0000.0000.0001.00
  Metric: 0      IS-Extended 0000.0000.0006.00
0000.0000.0002.00-00 0x00000007  0x94AE        764           0/0/0
Area Address: 49.0002
NLPID:         0x8E
IPv6 Address: 2001::1
Router Cap:    0.0.0.0
Maximum SID Depth:
  SRH maximum segments left : 4
  SRH maximum end pop : 4
  SRH maximum H.encaps : 4
  SRH maximum decapsulation sids : 4
SRV6 flags: 0
SR-Algorithm:
  Algorithm: 0
  Metric: 10      IS-Extended 0000.0000.0002.02
  Metric: 10      IPv6 2001::1/128
  Metric: 10      IPv6 2222::/64
  Metric: 1       IPv6 2001::/64
  SRV6 Locator:   (IPV6)2001::/64
  Algorithm: 0  flags: 0  metric: 0
  END SID: 2001::2001:0:0:0  flags:0  End-point behaviour: End with PSP (2)
  END SID: 2001::1001:0:0:0  flags:0  End-point behaviour: End with USP (3)
  END SID: 2001::801:0:0:0   flags:0  End-point behaviour: End with USD (28)
0000.0000.0002.02-00 0x00000006  0xD1EC        760           0/0/0
  Metric: 0      IS-Extended 0000.0000.0002.00
  Metric: 0      IS-Extended 0000.0000.0006.00
0000.0000.0003.00-00 0x0000000D  0x3163        962           0/0/0
Area Address: 49.0003
NLPID:         0x8E
IPv6 Address: 3001::1
Router Cap:    0.0.0.0
Maximum SID Depth:

```

```

    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
    SRV6 flags: 0
    SR-Algorithm:
      Algorithm: 0
    Metric: 10      IS-Extended 0000.0000.0006.03
    Metric: 10      IPv6 3001::1/128
    Metric: 1       IPv6 3001::/64
    Metric: 10      IPv6 3332::/64
    SRV6 Locator:   (IPv6)3001::/64
    Algorithm: 0 flags: 0 metric: 0
    END SID: 3001::2001:0:0:0 flags:0 End-point behaviour: End with PSP (2)
    END SID: 3001::1001:0:0:0 flags:0 End-point behaviour: End with USP (3)
    END SID: 3001::801:0:0:0 flags:0 End-point behaviour: End with USD (28)
0000.0000.0006.00-00 0x0000000D 0xE754 966 0/0/0
  Area Address: 49.0006
  NLPID: 0x8E
  IPv6 Address: 1112::2
  Metric: 10      IS-Extended 0000.0000.0001.01
  Metric: 10      IS-Extended 0000.0000.0002.02
  Metric: 10      IS-Extended 0000.0000.0006.03
  Metric: 10      IPv6 1112::/64
  Metric: 10      IPv6 2222::/64
  Metric: 10      IPv6 3332::/64
0000.0000.0006.03-00 0x00000004 0x9624 962 0/0/0
  Metric: 0      IS-Extended 0000.0000.0006.00
  Metric: 0      IS-Extended 0000.0000.0003.00

```

PE1#

PE2#show clns neighbors

```

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface  SNPA          State Holdtime Type Protocol
0000.0000.0006 xe5      e8c5.7a79.5723 Up      21      L2      IS-IS

```

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,

```

```

P - SRV6-POLICY,
v - vrf leaked

```

Timers: Uptime

IP Route Table for VRF "default"

```

C      ::1/128 via ::, lo, 01:08:07
i L2   1001::/64 [115/21] via fe80::eac5:7aff:fe79:5723, xe5, 01:07:46
i L2   1001::1/128 [115/30] via fe80::eac5:7aff:fe79:5723, xe5, 01:07:46
i L2   1112::/64 [115/20] via fe80::eac5:7aff:fe79:5723, xe5, 01:07:58
C      2001::1/128 via ::, lo, 01:08:07
C      2001::2:0:0:0/128, SRV6 END.DX2 SID
      via ::, lo, 01:08:05
C      2001::801:0:0:0/128, SRV6 END SID
      via ::, lo, 01:08:07
C      2001::1001:0:0:0/128, SRV6 END SID
      via ::, lo, 01:08:07
C      2001::2001:0:0:0/128, SRV6 END SID
      via ::, lo, 01:08:07
C      2001::6001:0:0:0/128, SRV6 END.X SID
      via fe80::eac5:7aff:fe79:5723, xe5, 01:08:01
C      2222::/64 via ::, xe5, 01:08:07
i L2   3001::/64 [115/21] via fe80::eac5:7aff:fe79:5723, xe5, 00:49:29

```

```

i L2    3001::1/128 [115/30] via fe80::eac5:7aff:fe79:5723, xe5, 00:49:29
i L2    3332::/64 [115/20] via fe80::eac5:7aff:fe79:5723, xe5, 00:49:34
C       fe80::/64 via ::, xe5, 01:08:07
PE2#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
0000.0000.0002.00-00* 0x00000006   0xDF9E       721           1/0/0
  Area Address: 49.0002
  NLPID:        0x8E
  IPv6 Address: 2001::1
  Router Cap:   0.0.0.0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  SR-Algorithm:
    Algorithm: 0
  Metric: 10      IPv6 2001::1/128
  Metric: 10      IPv6 2222::/64
  Metric: 1        IPv6 2001::/64
  SRV6 Locator:   (IPV6)2001::/64
  Algorithm: 0 flags: 0 metric: 0
  END SID: 2001::2001:0:0:0 flags:0 End-point behaviour: End with PSP (2)
  END SID: 2001::1001:0:0:0 flags:0 End-point behaviour: End with USP (3)
  END SID: 2001::801:0:0:0 flags:0 End-point behaviour: End with USD (28)

IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00 0x00000007   0x1FB7       639           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: 1112::1
  Router Cap:   0.0.0.0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  SR-Algorithm:
    Algorithm: 0
  Metric: 10      IS-Extended 0000.0000.0001.01
  Metric: 10      IPv6 1112::/64
  Metric: 10      IPv6 1001::1/128
  Metric: 1        IPv6 1001::/64
  SRV6 Locator:   (IPV6)1001::/64
  Algorithm: 0 flags: 0 metric: 0
  END SID: 1001::2001:0:0:0 flags:0 End-point behaviour: End with PSP (2)
  END SID: 1001::1001:0:0:0 flags:0 End-point behaviour: End with USP (3)
  END SID: 1001::801:0:0:0 flags:0 End-point behaviour: End with USD (28)
0000.0000.0001.01-00 0x00000005   0xD9E8       636           0/0/0
  Metric: 0        IS-Extended 0000.0000.0001.00
  Metric: 0        IS-Extended 0000.0000.0006.00
0000.0000.0002.00-00* 0x00000007   0x94AE       726           0/0/0
  Area Address: 49.0002
  NLPID:        0x8E
  IPv6 Address: 2001::1
  Router Cap:   0.0.0.0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  SR-Algorithm:

```



```

    Algorithm: 0
    Metric:    10          IS-Extended 0000.0000.0002.02
    Metric:    10          IPv6 2001::1/128
    Metric:    10          IPv6 2222::/64
    Metric:    1           IPv6 2001::/64
    SRV6 Locator: (IPV6)2001::/64
    Algorithm: 0 flags: 0 metric: 0
    END SID: 2001::2001:0:0:0 flags:0 End-point behaviour: End with PSP (2)
    END SID: 2001::1001:0:0:0 flags:0 End-point behaviour: End with USP (3)
    END SID: 2001::801:0:0:0 flags:0 End-point behaviour: End with USD (28)
0000.0000.0002.02-00* 0x00000006 0xD1EC 722 0/0/0
    Metric:    0          IS-Extended 0000.0000.0002.00
    Metric:    0          IS-Extended 0000.0000.0006.00
0000.0000.0003.00-00 0x0000000D 0x3163 923 0/0/0
    Area Address: 49.0003
    NLPID:      0x8E
    IPv6 Address: 3001::1
    Router Cap: 0.0.0.0
    Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
    SRV6 flags: 0
    SR-Algorithm:
    Algorithm: 0
    Metric:    10          IS-Extended 0000.0000.0006.03
    Metric:    10          IPv6 3001::1/128
    Metric:    1           IPv6 3001::/64
    Metric:    10          IPv6 3332::/64
    SRV6 Locator: (IPV6)3001::/64
    Algorithm: 0 flags: 0 metric: 0
    END SID: 3001::2001:0:0:0 flags:0 End-point behaviour: End with PSP (2)
    END SID: 3001::1001:0:0:0 flags:0 End-point behaviour: End with USP (3)
    END SID: 3001::801:0:0:0 flags:0 End-point behaviour: End with USD (28)
0000.0000.0006.00-00 0x0000000D 0xE754 927 0/0/0
    Area Address: 49.0006
    NLPID:      0x8E
    IPv6 Address: 1112::2
    Metric:    10          IS-Extended 0000.0000.0001.01
    Metric:    10          IS-Extended 0000.0000.0002.02
    Metric:    10          IS-Extended 0000.0000.0006.03
    Metric:    10          IPv6 1112::/64
    Metric:    10          IPv6 2222::/64
    Metric:    10          IPv6 3332::/64
0000.0000.0006.03-00 0x00000004 0x9624 923 0/0/0
    Metric:    0          IS-Extended 0000.0000.0006.00
    Metric:    0          IS-Extended 0000.0000.0003.00

PE2#

PE3#show clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface      SNPA              State Holdtime  Type Protocol
0000.0000.0006 ce3/4          e8c5.7a79.572f    Up      8          L2    IS-IS
PE3#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,
       P - SRV6-POLICY,
       v - vrf leaked
Timers: Uptime

```

```

IP Route Table for VRF "default"
C      ::1/128 via ::, lo, 01:10:25
i L2   1001::/64 [115/21] via fe80::eac5:7aff:fe79:572f, ce3/4, 00:49:58
i L2   1001::1/128 [115/30] via fe80::eac5:7aff:fe79:572f, ce3/4, 00:49:58
i L2   1112::/64 [115/20] via fe80::eac5:7aff:fe79:572f, ce3/4, 00:50:06
i L2   2001::/64 [115/21] via fe80::eac5:7aff:fe79:572f, ce3/4, 00:49:58
i L2   2001::1/128 [115/30] via fe80::eac5:7aff:fe79:572f, ce3/4, 00:49:58
i L2   2222::/64 [115/20] via fe80::eac5:7aff:fe79:572f, ce3/4, 00:50:06
C      3001::1/128 via ::, lo, 01:10:25
C      3001::2:0:0:0/128, SRV6 END.DX2 SID
      via ::, lo, 01:10:25
C      3001::801:0:0:0/128, SRV6 END SID
      via ::, lo, 01:10:25
C      3001::1001:0:0:0/128, SRV6 END SID
      via ::, lo, 01:10:25
C      3001::2001:0:0:0/128, SRV6 END SID
      via ::, lo, 01:10:25
C      3001::6001:0:0:0/128, SRV6 END.X SID
      via fe80::eac5:7aff:fe79:572f, ce3/4, 00:50:11
C      3332::/64 via ::, ce3/4, 00:53:02
C      fe80::/64 via ::, ce3/3, 00:55:17
PE3#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
0000.0000.0003.00-00* 0x0000000D  0x964D        893           1/0/0
  Area Address: 49.0003
  NLPID:        0x8E
  IPv6 Address: 3001::1
  Router Cap:   0.0.0.0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  SR-Algorithm:
    Algorithm: 0
  Metric:      10      IPv6 3001::1/128
  Metric:      1      IPv6 3001::/64
  Metric:      10     IPv6 3332::/64
  SRV6 Locator: (IPV6)3001::/64
    Algorithm: 0 flags: 0 metric: 0
    END SID: 3001::2001:0:0:0 flags:0 End-point behaviour: End with PSP (2)
    END SID: 3001::1001:0:0:0 flags:0 End-point behaviour: End with USP (3)
    END SID: 3001::801:0:0:0 flags:0 End-point behaviour: End with USD (28)

IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00 0x00000007  0x1FB7        603           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: 1112::1
  Router Cap:   0.0.0.0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  SR-Algorithm:
    Algorithm: 0
  Metric:      10      IS-Extended 0000.0000.0001.01
  Metric:      10     IPv6 1112::/64
  Metric:      10     IPv6 1001::1/128
  Metric:      1      IPv6 1001::/64
  SRV6 Locator: (IPV6)1001::/64

```

```

    Algorithm: 0  flags: 0  metric: 0
    END SID: 1001::2001:0:0:0  flags:0  End-point behaviour: End with PSP (2)
    END SID: 1001::1001:0:0:0  flags:0  End-point behaviour: End with USP (3)
    END SID: 1001::801:0:0:0  flags:0  End-point behaviour: End with USD (28)
0000.0000.0001.01-00  0x00000005  0xD9E8  600  0/0/0
    Metric: 0  IS-Extended 0000.0000.0001.00
    Metric: 0  IS-Extended 0000.0000.0006.00
0000.0000.0002.00-00  0x00000007  0x94AE  689  0/0/0
    Area Address: 49.0002
    NLPID: 0x8E
    IPv6 Address: 2001::1
    Router Cap: 0.0.0.0
    Maximum SID Depth:
        SRH maximum segments left : 4
        SRH maximum end pop : 4
        SRH maximum H.encaps : 4
        SRH maximum decapsulation sids : 4
    SRV6 flags: 0
    SR-Algorithm:
        Algorithm: 0
    Metric: 10  IS-Extended 0000.0000.0002.02
    Metric: 10  IPv6 2001::1/128
    Metric: 10  IPv6 2222::/64
    Metric: 1  IPv6 2001::/64
    SRV6 Locator: (IPv6)2001::/64
    Algorithm: 0  flags: 0  metric: 0
    END SID: 2001::2001:0:0:0  flags:0  End-point behaviour: End with PSP (2)
    END SID: 2001::1001:0:0:0  flags:0  End-point behaviour: End with USP (3)
    END SID: 2001::801:0:0:0  flags:0  End-point behaviour: End with USD (28)
0000.0000.0002.02-00  0x00000006  0xD1EC  685  0/0/0
    Metric: 0  IS-Extended 0000.0000.0002.00
    Metric: 0  IS-Extended 0000.0000.0006.00
0000.0000.0003.00-00* 0x0000000D  0x3163  888  0/0/0
    Area Address: 49.0003
    NLPID: 0x8E
    IPv6 Address: 3001::1
    Router Cap: 0.0.0.0
    Maximum SID Depth:
        SRH maximum segments left : 4
        SRH maximum end pop : 4
        SRH maximum H.encaps : 4
        SRH maximum decapsulation sids : 4
    SRV6 flags: 0
    SR-Algorithm:
        Algorithm: 0
    Metric: 10  IS-Extended 0000.0000.0006.03
    Metric: 10  IPv6 3001::1/128
    Metric: 1  IPv6 3001::/64
    Metric: 10  IPv6 3332::/64
    SRV6 Locator: (IPv6)3001::/64
    Algorithm: 0  flags: 0  metric: 0
    END SID: 3001::2001:0:0:0  flags:0  End-point behaviour: End with PSP (2)
    END SID: 3001::1001:0:0:0  flags:0  End-point behaviour: End with USP (3)
    END SID: 3001::801:0:0:0  flags:0  End-point behaviour: End with USD (28)
0000.0000.0006.00-00  0x0000000D  0xE754  891  0/0/0
    Area Address: 49.0006
    NLPID: 0x8E
    IPv6 Address: 1112::2
    Metric: 10  IS-Extended 0000.0000.0001.01
    Metric: 10  IS-Extended 0000.0000.0002.02
    Metric: 10  IS-Extended 0000.0000.0006.03
    Metric: 10  IPv6 1112::/64
    Metric: 10  IPv6 2222::/64
    Metric: 10  IPv6 3332::/64
0000.0000.0006.03-00  0x00000004  0x9624  887  0/0/0
    Metric: 0  IS-Extended 0000.0000.0006.00
    Metric: 0  IS-Extended 0000.0000.0003.00

```

```

PE3#

P1#show clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 3
Total number of adjacencies: 3
Tag 1: VRF : default
System Id      Interface  SNPA                State Holdtime  Type Protocol
0000.0000.0002 xe5       e8c5.7a85.0ad5      Up    5          L2   IS-IS
0000.0000.0003 xe17      5c07.5813.429a      Up    20         L2   IS-IS
0000.0000.0001 ce0       e8c5.7aa3.2cbf      Up    5          L2   IS-IS
P1#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, 01:10:54
i L2   1001::/64 [115/11] via fe80::eac5:7aff:fea3:2cbf, ce0, 01:10:33
i L2   1001::1/128 [115/20] via fe80::eac5:7aff:fea3:2cbf, ce0, 01:10:33
C      1112::/64 via ::, ce0, 01:10:54
i L2   2001::/64 [115/11] via fe80::eac5:7aff:fe85:ad5, xe5, 01:08:53
i L2   2001::1/128 [115/20] via fe80::eac5:7aff:fe85:ad5, xe5, 01:08:53
C      2222::/64 via ::, xe5, 01:09:46
i L2   3001::/64 [115/11] via fe80::5e07:58ff:fe13:429a, xe17, 00:51:00
i L2   3001::1/128 [115/20] via fe80::5e07:58ff:fe13:429a, xe17, 00:51:00
C      3332::/64 via ::, xe17, 00:53:26
C      fe80::/64 via ::, xe16, 00:56:06
P1#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
0000.0000.0006.00-00* 0x0000000C  0xD7C1        837           1/0/0
  Area Address: 49.0006
  NLPID:        0x8E
  IPv6 Address: 1112::2
  Metric:       10          IPv6 1112::/64
  Metric:       10          IPv6 2222::/64
  Metric:       10          IPv6 3332::/64

IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00 0x00000007  0x1FB7        553           0/0/0
  Area Address: 49.0001
  NLPID:        0x8E
  IPv6 Address: 1112::1
  Router Cap:   0.0.0.0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  Unknown Sub-TLV type 25 length 2
  SR-Algorithm:
    Algorithm: 0
  Metric:       10          IS-Extended 0000.0000.0001.01
  Metric:       10          IPv6 1112::/64
  Metric:       10          IPv6 1001::1/128
  Metric:       1          IPv6 1001::/64
0000.0000.0001.01-00 0x00000005  0xD9E8        549           0/0/0
  Metric:       0          IS-Extended 0000.0000.0001.00
  Metric:       0          IS-Extended 0000.0000.0006.00
0000.0000.0002.00-00 0x00000007  0x94AE        639           0/0/0

```

```

Area Address: 49.0002
NLPID:      0x8E
IPv6 Address: 2001::1
Router Cap:  0.0.0.0
Maximum SID Depth:
  SRH maximum segments left : 4
  SRH maximum end pop : 4
  SRH maximum H.encaps : 4
  SRH maximum decapsulation sids : 4
Unknown Sub-TLV type 25 length 2
SR-Algorithm:
  Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0002.02
Metric: 10      IPv6 2001::1/128
Metric: 10      IPv6 2222::/64
Metric: 1        IPv6 2001::/64
0000.0000.0002.02-00 0x00000006 0xD1EC      635      0/0/0
Metric: 0        IS-Extended 0000.0000.0002.00
Metric: 0        IS-Extended 0000.0000.0006.00
0000.0000.0003.00-00 0x0000000D 0x3163      836      0/0/0
Area Address: 49.0003
NLPID:      0x8E
IPv6 Address: 3001::1
Router Cap:  0.0.0.0
Maximum SID Depth:
  SRH maximum segments left : 4
  SRH maximum end pop : 4
  SRH maximum H.encaps : 4
  SRH maximum decapsulation sids : 4
Unknown Sub-TLV type 25 length 2
SR-Algorithm:
  Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0006.03
Metric: 10      IPv6 3001::1/128
Metric: 1        IPv6 3001::/64
Metric: 10      IPv6 3332::/64
0000.0000.0006.00-00* 0x0000000D 0xE754      842      0/0/0
Area Address: 49.0006
NLPID:      0x8E
IPv6 Address: 1112::2
Metric: 10      IS-Extended 0000.0000.0001.01
Metric: 10      IS-Extended 0000.0000.0002.02
Metric: 10      IS-Extended 0000.0000.0006.03
Metric: 10      IPv6 1112::/64
Metric: 10      IPv6 2222::/64
Metric: 10      IPv6 3332::/64
0000.0000.0006.03-00* 0x00000004 0x9624      837      0/0/0
Metric: 0        IS-Extended 0000.0000.0006.00
Metric: 0        IS-Extended 0000.0000.0003.00

Pl#

```

BGP

Validation for EVPN-ELINE SH

```

PE1#show bgp neighbors
BGP neighbor is 2001::1, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 1.1.1.1, remote router ID 2.2.2.2
  BGP state = Established, up for 00:29:15
  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 L2VPN EVPN: advertised and received
  Received 181 messages, 1 notifications, 0 in queue

```

```

Sent 181 messages, 2 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 0 seconds
Update source is lo
Bidirectional Forwarding Detection is enabled

For address family: L2VPN EVPN  BGP table version 6, neighbor version 4
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
3 accepted prefixes
Accepted AD:2 MACIP:0 MCAST:0 ESI:1 PREFIX:0
3 announced prefixes

Connections established 4; dropped 3
Local host: 1001::1, Local port: 38065
Foreign host: 2001::1, Foreign port: 179
Nexthop: 1.1.1.1
Nexthop global: 1001::1
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:29:20, due to BGP Notification received
Notification Error Message: (Cease/Other Configuration Change.)

BGP neighbor is 3001::1, 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 00:29:03
Last read 00:00:18, 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 126 messages, 2 notifications, 0 in queue
Sent 136 messages, 2 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 0 seconds
Update source is lo
Bidirectional Forwarding Detection is enabled

For address family: L2VPN EVPN  BGP table version 6, neighbor version 5
Index 2, Offset 0, Mask 0x4
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
1 accepted prefixes
Accepted AD:1 MACIP:0 MCAST:0 ESI:0 PREFIX:0
3 announced prefixes

Connections established 4; dropped 3
Local host: 1001::1, Local port: 40319
Foreign host: 3001::1, Foreign port: 179
Nexthop: 1.1.1.1
Nexthop global: 1001::1
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:29:08, due to BGP Notification received
Notification Error Message: (Cease/Other Configuration Change.)

PE1#
PE1#show bgp l2vpn evpn summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 6
1 BGP AS-PATH entries
0 BGP community entries
3 Configured ibgp ECMP multipath: Currently set at 3

Neighbor      V   AS   MsgRcv   MsgSen
TblVer  InQ   OutQ   Up/Down   State/PfxRcd   AD   MACIP   MCAST   ESI   PREFIX-ROUTE
2001::1      2     0     0         4    100    188     190     4     0     0 00:32:03      3

```

```

3001::1      4  100 134      145      5      0      0 00:31:51      1
      1      0      0      0      0

Total number of neighbors 2

Total number of Established sessions 2
PE1#show bgp l2vpn evpn
BGP table version is 6, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,
               1 - 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[10:10] VRF[ELINE_MH]:
* i   [1]:[0]:[42]:[3001::2:0:0:0]
      3001::1      0      100      0      i   3001::1      SRV6
* i   [1]:[00:00:00:11:11:11:00:00:00]:[12]:[2001::2:0:0:0]
      2001::1      0      100      0      i   2001::1      SRV6
*>    1001::1      0      100      32768      i   -----      SRV6
* i   [1]:[00:00:00:11:11:11:00:00:00]:[4294967295]:[0]
      2001::1      0      100      0      i   2001::1      SRV6

RD[20:20]
*>i   [1]:[00:00:00:11:11:11:00:00:00]:[12]:[2001::2:0:0:0]
      2001::1      0      100      0      i   2001::1      SRV6

RD[30:30]
*>i   [1]:[0]:[42]:[3001::2:0:0:0]
      3001::1      0      100      0      i   3001::1      SRV6

RD[17.0.0.0:64512] VRF[evpn-gvrf-1]:
*>   [1]:[00:00:00:11:11:11:00:00:00]:[4294967295]:[0]
      1001::1      0      100      32768      i   -----      SRV6
*>   [4]:[00:00:00:11:11:11:00:00:00]:[128,1001::1]
      1001::1      0      100      32768      i   -----      SRV6
* i   [4]:[00:00:00:11:11:11:00:00:00]:[128,2001::1]
      2001::1      0      100      0      i   2001::1      SRV6

RD[33.0.0.0:64512]
*>i   [1]:[00:00:00:11:11:11:00:00:00]:[4294967295]:[0]
      2001::1      0      100      0      i   2001::1      SRV6
*>i   [4]:[00:00:00:11:11:11:00:00:00]:[128,2001::1]
      2001::1      0      100      0      i   2001::1      SRV6

Total number of prefixes 10
PE1#

PE2#show bgp neighbors
BGP neighbor is 1001::1, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 2.2.2.2, remote router ID 1.1.1.1
  BGP state = Established, up for 00:29:33
  Last read 00:00:28, 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 181 messages, 2 notifications, 0 in queue
  Sent 183 messages, 1 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 0 seconds

```

```

Update source is lo
Bidirectional Forwarding Detection is enabled

For address family: L2VPN EVPN  BGP table version 5, neighbor version 3
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  3 accepted prefixes
  Accepted AD:2 MACIP:0 MCAST:0 ESI:1 PREFIX:0
  3 announced prefixes

  Connections established 4; dropped 3
  Local host: 2001::1, Local port: 179
  Foreign host: 1001::1, Foreign port: 38065
  Nexthop: 2.2.2.2
  Nexthop global: 2001::1
  Nexthop local: ::
  BGP connection: non shared network
  Last Reset: 00:29:33, due to Configuration Change (Cease Notification sent)
  Notification Error Message: (Cease/Other Configuration Change.)

BGP neighbor is 3001::1, 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 00:29:21
  Last read 00:00:11, 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 131 messages, 2 notifications, 0 in queue
  Sent 141 messages, 2 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 0 seconds
  Update source is lo
  Bidirectional Forwarding Detection is enabled

For address family: L2VPN EVPN  BGP table version 5, neighbor version 4
  Index 2, Offset 0, Mask 0x4
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  1 accepted prefixes
  Accepted AD:1 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  3 announced prefixes

  Connections established 4; dropped 3
  Local host: 2001::1, Local port: 179
  Foreign host: 3001::1, Foreign port: 36339
  Nexthop: 2.2.2.2
  Nexthop global: 2001::1
  Nexthop local: ::
  BGP connection: non shared network
  Last Reset: 00:29:26, due to BGP Notification received
  Notification Error Message: (Cease/Other Configuration Change.)

PE2#
PE2#show bgp l2vpn evpn summary
BGP router identifier 2.2.2.2, local AS number 100
BGP table version is 5
  1 BGP AS-PATH entries
  0 BGP community entries
  3  Configured ibgp ECMP multipath: Currently set at 3

Neighbor      V   AS   MsgRcv   MsgSen
TblVer  InQ   OutQ  Up/Down State/PfxRcd  AD  MACIP  MCAST  ESI  PREFIX-ROUTE
1001::1      2     0     0      4    100    192    192      3     0     0 00:33:02      3
3001::1      1     0     0      4    100    141    151     4     0     0 00:32:50      1

```



```

Total number of neighbors 2

Total number of Established sessions 2
PE2#show bgp l2vpn evpn
BGP table version is 5, local router ID is 2.2.2.2
Status codes: s suppressed, d damped, h history, a add-path, * valid, > best, i - internal,
               1 - 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[10:10]
*>i  [1]:[00:00:00:11:11:11:11:00:00:00]:[12]:[1001::2:0:0:0]
                                1001::1          0          100          0    i  1001::1          SRV6

RD[20:20] VRF[ELINE_MH]:
* i  [1]:[0]:[42]:[3001::2:0:0:0]
                                3001::1          0          100          0    i  3001::1          SRV6
* i  [1]:[00:00:00:11:11:11:11:00:00:00]:[12]:[1001::2:0:0:0]
                                1001::1          0          100          0    i  1001::1          SRV6
*>                                2001::1          0          100          32768 i  -----          SRV6
* i  [1]:[00:00:00:11:11:11:11:00:00:00]:[4294967295]:[0]
                                1001::1          0          100          0    i  1001::1          SRV6

RD[30:30]
*>i  [1]:[0]:[42]:[3001::2:0:0:0]
                                3001::1          0          100          0    i  3001::1          SRV6

RD[17.0.0.0:64512]
*>i  [1]:[00:00:00:11:11:11:11:00:00:00]:[4294967295]:[0]
                                1001::1          0          100          0    i  1001::1          SRV6
*>i  [4]:[00:00:00:11:11:11:11:00:00:00]:[128,1001::1]
                                1001::1          0          100          0    i  1001::1          SRV6

RD[33.0.0.0:64512] VRF[evpn-gvrf-1]:
*>  [1]:[00:00:00:11:11:11:11:00:00:00]:[4294967295]:[0]
                                2001::1          0          100          32768 i  -----          SRV6
* i  [4]:[00:00:00:11:11:11:11:00:00:00]:[128,1001::1]
                                1001::1          0          100          0    i  1001::1          SRV6
*>  [4]:[00:00:00:11:11:11:11:00:00:00]:[128,2001::1]
                                2001::1          0          100          32768 i  -----          SRV6

Total number of prefixes 10
PE2#

PE3#show bgp neighbors
BGP neighbor is 1001::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 00:29:32
  Last read 00:00:18, 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 134 messages, 1 notifications, 0 in queue
  Sent 130 messages, 2 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 0 seconds
  Bidirectional Forwarding Detection is enabled

```

```

For address family: L2VPN EVPN  BGP table version 6, neighbor version 5
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  3 accepted prefixes
  Accepted AD:2 MACIP:0 MCAST:0 ESI:1 PREFIX:0
  1 announced prefixes

  Connections established 4; dropped 3
  Local host: 3001::1, Local port: 179
  Foreign host: 1001::1, Foreign port: 40319
  Nexthop: 3.3.3.3
  Nexthop global: 3001::1
  Nexthop local: ::
  BGP connection: non shared network
  Last Reset: 00:29:32, due to Configuration Change (Cease Notification sent)
  Notification Error Message: (Cease/Other Configuration Change.)

BGP neighbor is 2001::1, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 3.3.3.3, remote router ID 2.2.2.2
  BGP state = Established, up for 00:29:32
  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 139 messages, 1 notifications, 0 in queue
  Sent 132 messages, 2 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 0 seconds
  Update source is lo
  Bidirectional Forwarding Detection is enabled

For address family: L2VPN EVPN  BGP table version 6, neighbor version 5
  Index 2, Offset 0, Mask 0x4
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  3 accepted prefixes
  Accepted AD:2 MACIP:0 MCAST:0 ESI:1 PREFIX:0
  1 announced prefixes

  Connections established 4; dropped 3
  Local host: 3001::1, Local port: 36339
  Foreign host: 2001::1, Foreign port: 179
  Nexthop: 3.3.3.3
  Nexthop global: 3001::1
  Nexthop local: ::
  BGP connection: non shared network
  Last Reset: 00:29:37, due to Configuration Change (Cease Notification sent)
  Notification Error Message: (Cease/Other Configuration Change.)

PE3#
PE3#show bgp l2vpn evpn summary
BGP router identifier 3.3.3.3, local AS number 100
BGP table version is 6
1 BGP AS-PATH entries
0 BGP community entries
3 Configured ibgp ECMP multipath: Currently set at 3

Neighbor      V  AS  MsgRcv  MsgSen
TblVer  InQ  OutQ  Up/Down  State/PfxRcd  AD  MACIP  MCAST  ESI  PREFIX-ROUTE
1001::1      2    0    0       4   100   144    141     5    0    0 00:33:15    3
2001::1      2    0    0       4   100   149    143     5    0    0 00:33:15    3

Total number of neighbors 2

```

```

Total number of Established sessions 2
PE3#show bgp l2vpn evpn
BGP table version is 6, 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[10:10]
*>i  [1]:[00:00:00:11:11:11:11:00:00:00]:[12]:[1001::2:0:0:0]
                                1001::1          0          100          0    i  1001::1      SRV6

RD[20:20]
*>i  [1]:[00:00:00:11:11:11:11:00:00:00]:[12]:[2001::2:0:0:0]
                                2001::1          0          100          0    i  2001::1      SRV6

RD[30:30] VRF[ELINE_MH]:
*>  [1]:[0]:[42]:[3001::2:0:0:0]
                                3001::1          0          100          32768    i  -----      SRV6
* i  [1]:[00:00:00:11:11:11:11:00:00:00]:[12]:[1001::2:0:0:0]
                                1001::1          0          100          0    i  1001::1      SRV6
* i  [1]:[00:00:00:11:11:11:11:00:00:00]:[12]:[1001::2:0:0:0]
                                2001::1          0          100          0    i  2001::1      SRV6
* i  [1]:[00:00:00:11:11:11:11:00:00:00]:[4294967295]:[0]
                                1001::1          0          100          0    i  1001::1      SRV6
* i  [1]:[00:00:00:11:11:11:11:00:00:00]:[4294967295]:[0]
                                2001::1          0          100          0    i  2001::1      SRV6

RD[17.0.0.0:64512]
*>i  [1]:[00:00:00:11:11:11:11:00:00:00]:[4294967295]:[0]
                                1001::1          0          100          0    i  1001::1      SRV6
*>i  [4]:[00:00:00:11:11:11:11:00:00:00]:[128,1001::1]
                                1001::1          0          100          0    i  1001::1      SRV6

RD[33.0.0.0:64512]
*>i  [1]:[00:00:00:11:11:11:11:00:00:00]:[4294967295]:[0]
                                2001::1          0          100          0    i  2001::1      SRV6
*>i  [4]:[00:00:00:11:11:11:11:00:00:00]:[128,2001::1]
                                2001::1          0          100          0    i  2001::1      SRV6

Total number of prefixes 9
PE3#

```

SRV6 EVPN-ELINE

Validation on SRV6 EVPN-ELINE

```

PE1#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:

EVPN:
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID              Nextthop              SRv6-Policy-Name
ELINE   >      ELINE_
MH      12              42                    3001::2:0:0:0        3001::1              None
PE1#show segment-routing srv6 services evpn

```

```

Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf          local-evpn-id  remote-evpn-
id      SID                Nexthop                    SRv6-Policy-Name
ELINE   >      ELINE_      42                      3001::2:0:0:0          3001::1          None
MH  12
PE1#show segment-routing srv6 sid
SRv6 Segment ID table:
SID                Operation      Nexthop                    Originator
+-----+-----+-----+-----+
1001::2:0:0:0      END.DX2      ::                        evpn:12
1001::801:0:0:0     END[usd]     ::                        nsm
1001::1001:0:0:0    END[usp]     ::                        nsm
1001::2001:0:0:0    END[psp]     ::                        nsm
1001::6001:0:0:0    END.X[psp]   fe80::eac5:7aff:fe79:573a aisis
PE1#show hsl srv6 evpn
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+-----+
12      3001::1      0 /PRI
/3      ce30      fe80::eac5:7aff:fe79:573a      3001::2:0:0:0      Active      0x2000ccda
PE1#show evpn srv6 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
=====
12          ----          1500      42          po100.3      --- Single Homed Port ---
          3001::1          1500      AC-NW      NW-SET

Total number of entries are 1
PE1#show evpn srv6 xconnect tunnel summary

Total number of entries: 1 [Installed: 1, Resolved: 0, Unresolved: 0]
PE1#show evpn srv6 xconnect tunnel sid
EVPN-SRV6 Network tunnel SID's
Evpn service type: ELINE
EVI-NAME: NA
PE IP: 3001::1
Status: Installed
Xconnect information
Local Ethernet Tag Id: 12
Local UC-SID: 1001::2:0:0:0
Remote Ethernet Tag Id: 42
Remote UC-SID: 3001::2:0:0:0
Tunnel policy mapped: --

Total number of entries are 1
PE1#show etherchannel summary
Aggregator po100 100100
Aggregator Type: Layer2
Admin Key: 0100 - Oper Key 0100

```

```

Link: xe3 (5033) sync: 1
Link: xe2 (5034) sync: 1
PE1#

PE2#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:

EVPN:
Service Flags vrf          local-evpn-id  remote-evpn-
id      SID                Nexthop          SRv6-Policy-Name
ELINE   >      ELINE_
MH  12          42                3001::2:0:0:0    3001::1          None
PE2#show segment-routing srv6 services evpn
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf          local-evpn-id  remote-evpn-
id      SID                Nexthop          SRv6-Policy-Name
ELINE   >      ELINE_
MH  12          42                3001::2:0:0:0    3001::1          None
PE2#show segment-routing srv6 sid
SRv6 Segment ID table:
SID                Operation  Nexthop          Originator
+-----+-----+-----+-----+
2001::2:0:0:0      END.DX2      ::              evpn:12
2001::801:0:0:0     END[usd]     ::              nsm
2001::1001:0:0:0     END[usp]     ::              nsm
2001::2001:0:0:0     END[psp]     ::              nsm
2001::6001:0:0:0     END.X[psp]   fe80::eac5:7aff:fe79:5723isis
PE2#show hsl srv6 evpn
TABLE: SRv6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+
12      3001::1      0 /PRI
/3      xe5      fe80::eac5:7aff:fe79:5723      3001::2:0:0:0      Active      0x2000ccd5
PE2#show evpn srv6 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
=====
12          ----          1500      42          po100.3      --- Single Homed Port ---
          3001::1          1500      AC-NW      NW-SET

Total number of entries are 1
PE2#show evpn srv6 xconnect tunnel summary

Total number of entries: 1 [Installed: 1, Resolved: 0, Unresolved: 0]
PE2#show evpn srv6 xconnect tunnel sid
EVPN-SRV6 Network tunnel SID's
Evpn service type: ELINE
EVI-NAME: NA
PE IP: 3001::1

```

```

    Status: Installed
Xconnect information
  Local Ethernet Tag Id: 12
  Local UC-SID: 2001::2:0:0:0
  Remote Ethernet Tag Id: 42
  Remote UC-SID: 3001::2:0:0:0
  Tunnel policy mapped: --

Total number of entries are 1
PE2#show etherchannel summary
  Aggregator po100 100100
  Aggregator Type: Layer2
  Admin Key: 0100 - Oper Key 0100
    Link: xe11 (5012) sync: 1
    Link: xe13 (5014) sync: 1
PE2#
PE3#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:

EVPN:
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID              Nexthop              SRv6-Policy-Name
ELINE   >      ELINE_
MH  42      ELINE_  12              1001::2:0:0:0      1001::1      None
ELINE   >      ELINE_
MH  42      ELINE_  12              2001::2:0:0:0      2001::1      None
PE3#show segment-routing srv6 services evpn
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID              Nexthop              SRv6-Policy-Name
ELINE   >      ELINE_
MH  42      ELINE_  12              1001::2:0:0:0      1001::1      None
ELINE   >      ELINE_
MH  42      ELINE_  12              2001::2:0:0:0      2001::1      None
PE3#show segment-routing srv6 sid
SRv6 Segment ID table:
SID              Operation      Nexthop              Originator
+-----+-----+-----+-----+
3001::2:0:0:0    END.DX2        ::                  evpn:42
3001::801:0:0:0   END[usd]        ::                  nsm
3001::1001:0:0:0  END[usp]        ::                  nsm
3001::2001:0:0:0  END[psp]        ::                  nsm
3001::6001:0:0:0  END.X[psp]      fe80::eac5:7aff:fe79:572fisis
PE3#show hsl srv6 evpn
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN |
| SEGMENT | CACHE | FEC_ID | | | |
| ID | FEC | TYPE/NHLFE-ID | IFNAME | STATUS | |
+-----+-----+-----+-----+-----+-----+-----+
42      1001::1      0 /PRI
/6      ce3/4 fe80::eac5:7aff:fe79:572f  1001::2:0:0:0      Active  0x2000cce0
42      2001::1      0 /PRI
/5      ce3/4 fe80::eac5:7aff:fe79:572f  2001::2:0:0:0      Active  0x2000ccdd
PE3#show evpn srv6 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
=====
42          ----          1500    12          ce2.3       00:00:00:11:11:11:00:00
2001::1      1500    AC-NW   NW-SET
1500      ----      ----
1001::1

Total number of entries are 1
PE3#show evpn srv6 xconnect tunnel summary

Total number of entries: 2 [Installed: 2, Resolved: 0, Unresolved: 0]
PE3#show evpn srv6 xconnect tunnel sid
EVPN-SRV6 Network tunnel SID's
Evpn service type: ELINE
EVI-NAME: NA
PE IP: 1001::1
Status: Installed
Xconnect information
Local Ethernet Tag Id: 42
Local UC-SID: 3001::2:0:0:0
Remote Ethernet Tag Id: 12
Remote UC-SID: 1001::2:0:0:0
Tunnel policy mapped: --
Evpn service type: ELINE
EVI-NAME: NA
PE IP: 2001::1
Status: Installed
Xconnect information
Local Ethernet Tag Id: 42
Local UC-SID: 3001::2:0:0:0
Remote Ethernet Tag Id: 12
Remote UC-SID: 2001::2:0:0:0
Tunnel policy mapped: --

Total number of entries are 2
PE3#

PE3#show hsl srv6 evpn-ecmp
TABLE: SRV6 EVPN-ECMP Table
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | ESI | ECMP |
| Detail | L3-FEC | VSI | |
| ID | FEC | | Group-ID | GPORT | fec-
cnt| ORIGINAL | DUPLICATE | |
+-----+-----+-----+-----+-----+-----+-----+-----+
42 1001::1 00:00:00:11:11:11:11:00:00:00 0x20000001 0x98000001 2 0x
2000ccde 0x2000cce0 0
42 2001::1 00:00:00:11:11:11:11:00:00:00 0x20000001 0x98000001 2 0x
2000ccd9 0x2000cce1 0
PE3#
```

Configure SRv6 with EVPN ELAN

Overview

The Ethernet Virtual Private Network - Ethernet LAN (EVPN ELAN) SRv6 feature integrates Segment Routing over IPv6 (SRv6) technology with EVPN signaling mechanisms to deliver multipoint-to-multipoint VPN services efficiently. To overcome the limitations of traditional L2VPN technologies such as Virtual Private LAN Services

(VPLS), SRv6 EVPN ELAN utilizes BGP extensions and integrates the control planes for multiple VPN services. This approach separates forwarding and control planes, enabling a more efficient and effective network architecture.

Feature Characteristics

- Utilizes BGP extensions for MAC address learning and advertisement, enhancing control-plane based MAC learning.
- Supports local MAC address learning using ARP and remote MAC/IP address learning through MAC/IP advertisement routes.
- Advertises MAC/IP routes to reduce broadcast traffic volume and save bandwidth resources.
- Supports Inclusive Multicast Ethernet Tag Route (IMET) routes for efficient delivery of Broadcast, unknown Unicast, and Multicast (BUM) traffic.

Benefits

- Enhances network scalability and efficiency by moving MAC address learning to the control plane.
- Reduces network complexity and signaling messages by leveraging BGP for PE communication.
- Optimizes resource consumption by locally storing MAC and IP address information.
- Enables fast convergence and traffic balancing, improving overall network performance.

Prerequisites

Compatible network devices supporting SRv6 and EVPN technologies.

EVPN ELAN Configuration

Configure EVPN ELAN services with the SRv6 transport option, enabling enhanced scalability, flexibility, and operational efficiency.

The following configuration enables EVPN ELAN service specific to SRv6 transport.

Topology

The topology includes with edge and intermediate nodes, utilizing SRv6 functionality, and various routing protocols to ensure efficient communication and service delivery within the provider network.

Figure 36. SRv6 EVPN ELAN Topology



Provider Edge Nodes (PE1 and PE2)

These intermediate nodes within the provider network may or may not be SRv6-capable routers.

Perform the following steps to configure SRv6 EVPN functionality on PE nodes with ISIS as IGP, appropriate MAC-VRF, BGP and EVPN EVI settings:

1. Configure Loopback Interfaces:

- Access interface configuration mode for the loopback interface(`interface lo`).

- Assign an IPv6 address to the loopback interface using the `ipv6 address` command followed by the desired IPv6 address and subnet mask (`ipv6 address 1001::1/128`).
- Configure OSPF for IPv6 on the loopback interface using the `ipv6 router ospf` command, specifying the OSPF area, tag, and instance ID (`ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0`).
- Configure IS-IS for IPv6 on the loopback interface using the `ipv6 router isis` command, specifying the IS-IS process ID (`ipv6 router isis 1`).

```
PE1(config)#interface lo
PE1(config-if)#ipv6 address 1001::1/128
PE1(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
PE1(config-if)#ipv6 router isis 1
PE1(config-if)#exit
```

2. Configure Network interfaces:

- Access interface configuration mode for the desired network interface (`interface xe9`).
- Assign an IPv6 address to the interface using the `ipv6 address` command followed by the desired IPv6 address and subnet mask (`ipv6 address cafe:1:1::1/64`).
- Configure the MTU for the interface (`mtu 9216`).
- Configure OSPF for IPv6 on the interface using the `ipv6 router ospf` command, specifying the OSPF area, tag, and instance ID (`ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0`).
- Configure IS-IS for IPv6 on the interface using the `ipv6 router isis` command, specifying the IS-IS process ID (`ipv6 router isis 1`).

```
PE1(config)#interface xe9
PE1(config-if)#ipv6 address cafe:1:1::1/64
PE1(config-if)#mtu 9216
PE1(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
PE1(config-if)#ipv6 router isis 1
```

3. In Global configuration mode, perform the following:

- Enable EVPN SRv6 for EVPN on the router, allowing for flexible and scalable IPv6-based service delivery.

```
PE1(config)# evpn srv6 enable
```

- Configure global IPv6 address for SRv6 functionality in the EVPN on the router:

```
PE1(config)# evpn srv6 ip-global 1001::1
```

- Configure QOS.

```
PE1(config)#qos enable
```

- Define SRv6 locators to be used in the EVPN configuration.

```
PE1(config)# segment-routing srv6
PE1(config-srv6)# locators
PE1(config-locator)# locator PE1_locator
PE1(config-locator)# prefix 1001::/64
PE1(config-locator)# exit-locators
PE1(config-srv6)# exit-srv6
```

4. Configure ISIS Settings:

- Access ISIS configuration mode and provide the ISIS process ID (`router isis 1`).
- Specify the ISIS routing level using the `is-type` (`is-type level-2-only`).
- Configure the metric-style wide (`metric-style wide`).
- Enable dynamic hostname assignment.

- Configure the NET address (net 49.0001.0000.0000.0001.00).
- Enter address-family configuration mode for IPv6 (address-family ipv6).
- Configure segment routing with SRv6 (segment-routing srv6)

```
PE1(config)#router isis 1
PE1(config-router)#is-type level-2-only
PE1(config-router)#metric-style wide
PE1(config-router)#dynamic-hostname
PE1(config-router)#net 49.0001.0000.0000.0001.00
PE1(config-router)#address-family ipv6
PE1(config-router-af)#segment-routing srv6
PE1(config-router-af-srv6)#srv6-locator PE1_locator
PE1(config-router-af-srv6)#exit-srv6
PE1(config-router-af)# exit-address-family
```

5. Perform the BGP Configuration:

```
PE1(config)#router bgp 65010
PE1(config-router)#bgp router-id 1.1.1.1
PE1(config-router)#neighbor 2001::1 remote-as 65010
PE1(config-router)#neighbor 2001::1 update-source lo
PE1(config-router)#address-family l2vpn evpn
PE1(config-router-af)#neighbor 2001::1 activate
PE1(config-router-af)#exit-address-family
PE1(config-router)#exit
```

6. Create MAC VRF:

```
PE1(config)#mac vrf PE1_PE2_ELAN
PE1(config-vrf)#rd 1.1.1.1:2000
PE1(config-vrf)#route-target both 2000:2000
```

7. Define the EVI instance and SRv6 for the EVI with the MAC VRF Mapping specified locator:

```
PE1(config)#evpn srv6 id 2000
PE1(config)#host-reachability-protocol evpn-bgp PE1_PE2_ELAN
PE1(config)# locator PE1_locator
PE1(config)# exit

PE1(config)#interface xe6.2000 switchport
PE1(config-if)#encapsulation dot1q 2000
PE1(config-if)#mtu 9216
PE1(config-if)#access-if-evpn
PE1(config-access-if)#map vpn-id 2000
```

Configuration Snapshot

PE1

SRv6 EVPN Single-Homing on PE1

```
evpn srv6 enable
!
mac vrf PE1_PE2_ELAN
  rd 1.1.1.1:2000
  route-target both 2000:2000
!
qos enable
!
evpn srv6 ip-global 1001::1
!
evpn srv6 id 2000
  host-reachability-protocol evpn-bgp PE1_PE2_ELAN
  locator PE1_locator
!
```

```
hostname PE1
!
router-id 1.1.1.1
!
segment-routing
  srv6
    locators
      locator PE1_locator
        prefix 1001::/64
        exit-locator
          !
        exit-locators
          !
      exit-srv6
        !
    !
  !
interface lo
  ip address 127.0.0.1/8
  ipv6 address ::1/128
  ipv6 address 1001::1/128
  ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
  ipv6 router isis 1
  !
interface xe6
  mtu 9216
  !
interface xe6.2000 switchport
  encapsulation dot1q 2000
  mtu 9216
  access-if-evpn
    map vpn-id 2000
  !
interface xe9
  ipv6 address cafe:1:1::1/64
  mtu 9216
  ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
  ipv6 router isis 1
  !
router isis 1
  is-type level-2-only
  metric-style wide
  dynamic-hostname
  net 49.0001.0000.0000.0001.00
  !
  address-family ipv6
    segment-routing srv6
      srv6-locator PE1_locator
    exit-srv6
      !
    exit-address-family
      !
  !
router bgp 65010
  bgp router-id 1.1.1.1
  neighbor 2001::1 remote-as 65010
  neighbor 2001::1 update-source lo
  !
  address-family l2vpn evpn
    neighbor 2001::1 activate
  exit-address-family
    !
  exit
  !
```

P1**SRv6 EVPN ELAN Single-Homing on P1**

```
hostname P1
!
qos enable
!
router-id 1.1.1.11
!
interface lo
 ip address 127.0.0.1/8
 ipv6 address ::1/128
 ipv6 address 1101::1/128
 ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
 ipv6 router isis 1
!
interface xe6
 ipv6 address cafe:1:11::2/64
 mtu 9216
 ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
 ipv6 router isis 1
!
interface xe7
 ipv6 address cafe:11:21::1/64
 mtu 9216
 ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
 ipv6 router isis 1
!
router isis 1
 is-type level-2-only
 metric-style wide
 dynamic-hostname
 net 49.0001.0000.0000.0011.00
!
address-family ipv6
 exit-address-family
!
```

PE2**SRv6 EVPN ELAN Single-Homing on PE2**

```
evpn srv6 enable
!
mac vrf PE1_PE2_ELAN
 rd 1.1.1.2:2000
 route-target both 2000:2000
!
qos enable
!
evpn srv6 ip-global 2001::1
!
evpn srv6 id 2000
 host-reachability-protocol evpn-bgp PE1_PE2_ELAN
 locator PE2_locator
!
hostname PE2
!
router-id 1.1.1.2
!
segment-routing
 srv6
  locators
   locator PE2_locator
```

```

    prefix 2001::/64
    exit-locator
    !
    exit-locators
    !
    exit-srv6
    !
    !
interface lo
ip address 127.0.0.1/8
ipv6 address ::1/128
ipv6 address 2001::1/128
ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
ipv6 router isis 1
!
interface xe5
ipv6 address cafe:11:21::2/64
mtu 9216
ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0
ipv6 router isis 1
!
interface xe8
mtu 9216
!
interface xe8.2000 switchport
encapsulation dot1q 2000
access-if-evpn
map vpn-id 2000
!
router isis 1
is-type level-2-only
metric-style wide
dynamic-hostname
net 49.0001.0000.0000.0002.00
!
address-family ipv6
segment-routing srv6
    srv6-locator PE2_locator
exit-srv6
!
exit-address-family
!
router bgp 65010
bgp router-id 1.1.1.2
neighbor 1001::1 remote-as 65010
neighbor 1001::1 update-source lo
!
address-family l2vpn evpn
neighbor 1001::1 activate
exit-address-family
!
exit
!

```

Validation

PE1

The following show outputs displays the ISISv6 neighbour and routing information of the PE1.

```
PPE1#sh clns neighbors
```

```

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface      SNPA              State Holdtime  Type Protocol
P1             xe9              80a2.355b.7008    Up    24         L2    IS-IS
PE1#

PE1#sh clns neighbors detail

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface      SNPA              State Holdtime  Type Protocol
P1             xe9              80a2.355b.7008    Up    21         L2    IS-IS
  L1 Adjacency ID: 1
  L2 Adjacency ID: 2
  Uptime: 00:53:18
  Area Address(es): 49.0001
  IPv6 Address(es): fe80::82a2:35ff:fe5b:7008
  Level-2 Protocols Supported: IPv6
  Adjacency advertisement: Advertise

PE1#sh 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,
      P - SRV6-POLICY,
      v - vrf leaked
Timers: Uptime

IP Route Table for VRF "default"
C      ::1/128 via ::, lo, 00:56:00
C      1001::1/128 via ::, lo, 00:55:11
C      1001::6001:0:0:0/128, SRV6 END.X SID
      via fe80::82a2:35ff:fe5b:7008, xe9, 00:53:22
i L2   1101::1/128 [115/20] via fe80::82a2:35ff:fe5b:7008, xe9, 00:53:07
i L2   2001::/64 [115/21] via fe80::82a2:35ff:fe5b:7008, xe9, 00:37:00
i L2   2001::1/128 [115/30] via fe80::82a2:35ff:fe5b:7008, xe9, 00:37:00
C      cafe:1:1::/64 via ::, xe9, 00:53:23
i L2   cafe:1:11::/64 [115/20] via fe80::82a2:35ff:fe5b:7008, xe9, 00:53:07
i L2   cafe:2:3::/64 [115/30] via fe80::82a2:35ff:fe5b:7008, xe9, 00:37:00
i L2   cafe:11:3::/64 [115/20] via fe80::82a2:35ff:fe5b:7008, xe9, 00:53:07
i L2   cafe:11:21::/64 [115/20] via fe80::82a2:35ff:fe5b:7008, xe9, 00:38:40
C      fe80::/64 via ::, xe9, 00:53:23
PE1#

      2001::1              None

```

PE1

The following show outputs displays the BGP validation for EVPN ELAN.

```

PE1#sh bgp l2vpn evpn summary
BGP router identifier 1.1.1.1, local AS number 65010
BGP table version is 27
1 BGP AS-PATH entries
0 BGP community entries

Neighbor      V  AS  MsgRcv  MsgSen  TblVer  InQ  OutQ  Up/Down  State/P
fxRcd      AD
MACIP  MCAST ESI  PREFIX-ROUTE
2001::1          4
65010          151      185      27      0      0 00:24:07      1      0      0      1

```

```

0      0

Total number of neighbors 1

Total number of Established sessions 1
PE1#sh ip bgp neighbors
BGP neighbor is 2001::1, remote AS 65010, local AS 65010, internal link, peer index: 7
  BGP version 4, local router ID 1.1.1.1, remote router ID 1.1.1.2
  BGP state = Established, up for 00:24:12
  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 L2VPN EVPN: advertised and received
  Received 148 messages, 4 notifications, 0 in queue
  Sent 179 messages, 6 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 27, neighbor version 27
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  1 accepted prefixes
  Accepted AD:0 MACIP:0 MCAST:1 ESI:0 PREFIX:0
  3 announced prefixes

  Connections established 9; dropped 8
  Local host: 1001::1, Local port: 179
  Foreign host: 2001::1, Foreign port: 45691
  TCP MSS: (0), Advertise TCP MSS: (9156), Send TCP MSS: (9156),  Receive TCP MSS: (536)
  Sock FD : (28)
  Nexthop: 1.1.1.1
  Nexthop global: 1001::1
  Nexthop local: ::
  BGP connection: non shared network
  Last Reset: 00:24:12, due to BGP Notification received
  Notification Error Message: (Cease/Other Configuration Change.)

```

PE1

The following show outputs displays the SRv6 EVPN ELAN validation.

```

PE1#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:

EVPN:
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID          Nexthop          SRv6-Policy-Name
ELAN    >      PE1_PE2_ELAN
2000    NA          2001::4:0:0:0    2001::1          None
PE1#show segment-routing srv6 services evpn
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID          Nexthop          SRv6-Policy-Name
ELAN    >      PE1_PE2_ELAN
2000    NA          2001::4:0:0:0    2001::1          None
PE1#show segment-routing srv6 sid
SRv6 Segment ID table:
SID          Operation  Nexthop          Originator
+-----+-----+-----+-----+
1001::3:0:0:0  END.DT2U  ::              evpn:2000
1001::4:0:0:0  END.DT2M  ::              evpn:2000
1001::801:0:0:0 END[usd]  ::              nsm

```

```

1001::1001:0:0:0      END[usp]      ::              nsm
1001::2001:0:0:0      END[psp]      ::              nsm
1001::6001:0:0:0      END.X[psp]    fe80::82a2:35ff:fe5b:7008isis
PE1#
PE1#show hsl srv6 evpn
TABLE: SRV6 EVPN Table
+-----+-----+-----+-----+-----+-----+-----+-----+
| EVPN | DESTINATION | POLICY-ID/ | OUT | NEXTHOP | EVPN | |
| UC SID | | UC | | EVPN MC SID | VSI |
| ID | | FEC | | TYPE/NHLFE-ID | IFNAME |
| | | | | | STATUS | FEC_ |
+-----+-----+-----+-----+-----+-----+-----+
2000      2001::1      0      /PRI/4      xe9      fe80::82a2:35ff:fe5b:7008
::              2001::4:0:0:0      4154
PE1#
PE1#show evpn srv6 id 2000
EVPN-SRv6 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
-----
2000     ----      L2      NW      ----      ----      ----      ----
          1001::1      2001::1
2000     ----      --      AC      xe6.2000  --- Single Homed Port --- ----
          ----      ----

Total number of entries are 2

Note: Refer sub-interface config for VLAN information.
PE1#show evpn srv6 tunnel summary

Total number of entries: 1 [Installed: 1, Resolved: 0, Unresolved: 0]
PE1#show evpn srv6 tunnel sid
EVPN-SRv6 Network tunnel SID's
Evpn service type: ELAN, evi: 2000, evi-name: , status: Installed
PE IP: 2001::1
Tunnel information
  local UC-SID: 1001::3:0:0:0, local MC-SID: 1001::4:0:0:0
  remote UC-SID: ::, remote MC-SID: 2001::4:0:0:0
Tunnel policy mapped: --

Total number of entries are 1
PE1#

```

Implementation Examples

The SRv6 technology can be used to implement different use cases, such as MAC/IP Advertisement Route and IMET Route over SRv6 Core Propagation. In both cases, the SRv6-enabled routers learn MAC address information from the packets they receive and cache it in the forwarding tables, which helps optimize resource consumption and improve overall network performance. The SRv6 technology also helps reduce network complexity by leveraging BGP for PE communication and enables fast convergence and traffic balancing.

CLI Commands

The EVPN ELAN SRv6 introduces the following configuration commands:

- `evi-name`

- `evpn srv6 mac-ageing-time`
- `arp-nd refresh timer`
- `mac-holdtime`
- `show evpn srv6`
- `show evpn srv6 arp-cache`
- `show evpn srv6 mac-table`
- `show evpn srv6 nd-cache`
- `show evpn srv6 route-count`
- `show evpn srv6 static host state`

evi-name

Use this command to name the EVPN MPLS ID.

Use `no` parameter of this command to remove the name of the EVPN SRv6 ID.

Command Syntax

```
evi-name <WORD>
no evi-name
```

Parameters

WORD

EVI name of max size 10 characters and should not be only numeric.

Default

None

Command Mode

EVPN SRv6 mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to enable srv6 for EVPN.

```
#configure terminal
(config)#evpn srv6 id 3
(config-evpn-srv6)#evi-name ELAN
(config-evpn-srv6)#exit
```

evpn srv6 mac-ageing-time

Use this command to set the dynamically learned MAC aging time.

Use `no` parameter of this command to set the age out the MACs in hardware to its default.

Command Syntax

```
evpn srv6 mac-ageing-time <10-572>  
no evpn srv6 mac-ageing-time
```

Parameters

mac-ageing-time<10-572>

EVI name of max size 10 characters and should not be only numeric.

Default

Age out time to 300 seconds

Command Mode

Config mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to configure `evpn srv6 mac-ageing-time`:

```
#configure terminal  
(config)#evpn srv6 mac-ageing-time 10
```

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 `no` parameter of this command to remove the configuration.



Notes:

- Not applicable for the AC port which is mapped with ELINE/Xconnect Service.
- 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 srv6 arp-nd refresh-timer <3-190>  
no evpn srv6 arp-nd refresh-timer
```

Parameters

arp-nd refresh-timer<3-190>

Sets the refresh timer value for ARP and ND cache entries on a networking device.

Default

Disabled

Command Mode

Evpn mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to configure evpn srv6 arp-nd refresh-timer:

```
(config)#evpn srv6 arp-nd refresh-timer 100
(config)#no evpn srv6 arp-nd refresh-timer
```

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 neighbours. 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 address enters the discard state, traffic associated with it is dropped. This rule applies exclusively to MAC addresses or MAC-IP pairs configured manually.

Command Syntax

```
mac-holdtime <-1-300>
no mac-holdtime
```

Parameters

<-1-300>

MAC hold time in seconds. Specify -1 to never expire state.

Default

Zero second

Command Mode

EVPN SRv6 mode and ACC_IF mode.



Note: When set in both modes, the preference is given to the ACC_IF mode value for the corresponding access port.

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to configure mac-holdtime for evpn srv6:

```
#configure terminal
(config)#evpn srv6 id 3
(config-evpn-srv6) #mac-holdtime -1
(config-evpn-srv6) #exit
```

show evpn srv6

Use this command to display the EVPN Information.

Command Syntax

```
show evpn srv6 ((tunnel (| sid | summary) | id <1-16777215>)|)
```

Parameters

tunnel sid

Displays Segment Identifier (SID) used in Segment Routing (SR) networks to identify a tunnel.

tunnel summary

Provides a summarized view of SRv6 configurations and statuses.

tunnel id <1-16777215>

Displays information related to the specified SRv6 tunnel or SID identified by its numerical ID. The ID range is from 1 to 16777215.

Default

None

Command Mode

Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to display the show output of evpn srv6 tunnel.

```
PE1# show evpn srv6 tunnel sid
EVPN-SRV6 Network tunnel SID's
  Evpn service type: ELAN, evi: 10, evi-name: , status: Installed
  PE IP: 2001::3
    Tunnel information
      local UC-SID: cafe:aaaa:1:0:2::, local MC-SID: cafe:aaaa:1:0:3::
      remote UC-SID: cafe:aaaa:3:0:2::, remote MC-SID: cafe:aaaa:3:0:3::
    Tunnel policy mapped: --
  Evpn service type: ELAN, evi: 10, evi-name: , status: Installed
  PE IP: 2001::2
    Tunnel information
      local UC-SID: cafe:aaaa:1:0:2::, local MC-SID: cafe:aaaa:1:0:3::
      remote UC-SID: cafe:aaaa:2:0:2::, remote MC-SID: cafe:aaaa:2:0:3::
    Tunnel policy mapped: --

Total number of entries are 2
```

show evpn srv6 arp-cache

Use this command to display the ARP cache information.

Command Syntax

```
show evpn srv6 arp-cache (evid <1-16777215>|) (summary |)
```

Parameters**arp-cache**

Displays ARP cache information for all EVPN instances.

evid <1-16777215>

Displays ARP cache information specific to the EVPN instance identified by its Ethernet Segment Identifier (EVID). The EVID range is from 1 to 16777215.

summary

Provides a summarized view of the ARP cache information.

Default

None

Command Mode

Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to display the show output of evpn srv6 arp-cache

```
PE1#show evpn srv6 arp-cache
SRV6-EVPN ARP-CACHE Information
=====
EVPN-ID   Ip-Addr      Mac-Addr      Type           Age-Out  Retries-Left
-----
10        7.7.7.7      0020.9400.0004 Static Local    ----
10        192.85.1.3   0010.9400.0003 Dynamic Remote  ----
10        192.85.1.4   0010.9400.0004 Dynamic Local   ----
Total number of entries are 3
```

show evpn srv6 mac-table

Use this command to display the host MAC address table.

Command Syntax

```
show evpn srv6 mac-table (hardware |) (evid <1-16777215>|) (summary |)
```

Parameters**mac-table**

Displays the EVPN SRv6 MAC address table.

evid <1-16777215>

Specifies the EVPN Instance Identifier (EVI) for which you want to display the SRv6 MAC table information. The range for the EVI ID is from 1 to 16777215.

hardware

Displays Host mac addresses table from hardware.

summary

Provides a summarized view of Host mac addresses table from hardware.

Default

None

Command Mode

Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to display the show output of `evpn srv6 mac-table`
`PE1#show evpn srv6 mac-table`

EVPN SRV6 MAC Entries							
VNID Ip/ESI	Interface	VlanId	In-VlanId	Mac-Addr Type	VTEP- Status	MAC move	AccessPortDesc
10 2001::3	----	----	----	0001.9400.0003 Static Remote	-----	0	-----
10 2001::3	----	----	----	0011.9400.0003 Static Remote	-----	0	-----
10 2001::3	----	----	----	0011.9401.0003 Static Remote	-----	0	-----
10 2001::1	xe29.100	----	----	0020.9400.0003 Static Local	-----	0	-----
10 2001::1	xe29.100	----	----	0030.9400.0003 Static Local	-----	0	-----

Total number of entries are : 5

show evpn srv6 nd-cache

Use this command to display the Neighbor Discovery (ND) cache information.

Command Syntax

```
show evpn srv6 nd-cache (evid <1-16777215>|) (summary |)
```

Parameters**nd-cahce**

Displays the EVPN SRv6 ND table.

evid<1-16777215>

Displays ND cache information specific to the EVPN instance identified by its Ethernet Segment Identifier (EVID). The EVID range is from 1 to 16777215.

Summary

Provides a summarized view of the ND cache information.

Default

None

Command Mode

Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to display the show output of evpn srv6 nd-cache:

```
PE1#show evpn srv6 nd-cache
SRV6-EVPN ND-CACHE Information
=====
EVPN-ID  Ip-Addr                Mac-Addr                Type                Age-Out  Retries-Left
-----
10       1111::33                0011.9401.0003 Static Remote      ----
10       2222::22                0011.9401.0002 Static Remote      ----
Total number of entries are 2
```

show evpn srv6 route-count

Use this command to display the EVPN active route (MAC-IP.MAC-IPv6 and MAC-only) count information.

Command Syntax

```
show evpn srv6 route-count (|evid <1-16777215>)
```

Parameters**evid <1-16777215>**

Displays the count of SRv6 routes specific to the EVPN instance identified by its EVID. The EVID range is from 1 to 16777215.

Default

None

Command Mode

Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to display the show output of evpn srv6 route-count

```
PE1#show evpn srv6 route-count
```

```

EVPN-SRv6 Active route count information
=====
Max supported route count   : 131072
Active route count: 8

```

```

-----
VNID      Total      MACONLY  MACIPv4  MACIPv6
-----
10         8          4         2         2

```

Total number of entries are 1

PE1#

PE1#show evpn srv6 route-count evid 10

```

EVPN-SRv6 Active route count information
=====
Max supported route count   : 131072
Active route count: 8

```

```

-----
VNID      Total      MACONLY  MACIPv4  MACIPv6
-----
10         8          4         2         2

```

Total number of entries are 1

show evpn srv6 static host state

Use this command to display the state of the host which is configured statically.

Command Syntax

```
show evpn srv6 static host state
```

Parameters

None

Default

None

Command Mode

Exec mode

Applicability

Introduced in OcNOS version 6.5.1.

Example

The following example illustrates to display the show output of evpn srv6 static host status

```

PPE1#show evpn srv6 static host status
SRv6 Static Host Information
=====

```

```

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

```

```

VNID      Ifname      Outer-Vlan Inner-vlan Ip-Addr      Mac-
Addr      Status
-----

```



```

10      xe29.100    ---      ---      0.0.0.0      0020.9400.0003
Active
10      xe29.100    ---      ---      2001::9      0030.9400.0003
Inactive

Total number of entries are 2

```

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
Ethernet VPN (EVPN)	A solution that provides Ethernet multipoint services over MPLS networks, enabling control-plane-based MAC learning in the core.
Virtual Private LAN Service (VPLS)	An early MPLS VPN technology that provides multipoint-to-multipoint wide-area Ethernet services for enterprise users.
MP-BGP Protocol	Multi-Protocol Border Gateway Protocol, used for control-plane MAC learning in EVPN instances.
Control Plane	The part of a network responsible for routing protocols, forwarding tables, and other control functions.
Data Plane	The part of a network responsible for forwarding user data based on the information in the control plane.
Route Reflector (RR)	A device in a network that helps to reduce the number of IBGP connections required in a full-mesh topology by reflecting routes from one IBGP speaker to another.
Media Access Control (MAC) Address	A unique identifier assigned to network interfaces for communication at the data link layer of a network segment.
BGP Extensions	Additional functionality added to the Border Gateway Protocol (BGP) to support specific requirements or features.
IMET Route	A route type in EVPN used for Broadcast, Unknown Unicast, and Multicast (BUM) traffic delivery across EVPN networks.
Ethernet Segment Route	A route type in EVPN used in multi-homing scenarios and for Designated Forwarder Election.
Ingress Replication (IR)	A technique used in multicast routing to replicate multicast traffic at the ingress router and forward it to multiple egress routers.
Designated Forwarder (DF)	In EVPN, the PE responsible for sending broadcast, unknown multicast, and multicast (BUM) traffic to the CE on a particular Ethernet Segment.

BGP Link State OSPFv3 with SRv6

This section contains configurations of BGP-LS OSPFv3 with SRv6.

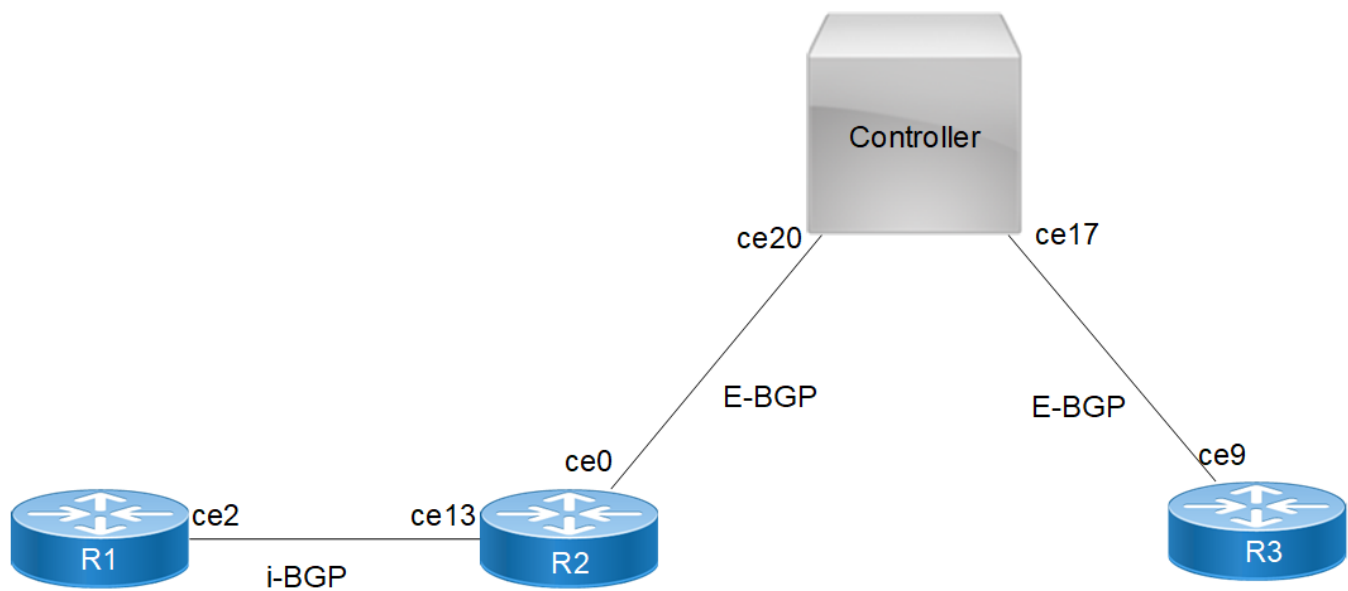
BGP Link-State (BGP-LS) is used to the topology of the domain using nodes, links, prefixes NLRI and SRv6 SID NLRI. This feature adds the capability to report SRv6 Segment Identifier and Network Layer Reachability Information (NLRI).

The following NLRI has been to the BGP-LS protocol to support SRv6:

- Node NLRI: SRv6 Capabilities, SRv6 MSD types
- Link NLRI: End.X, LAN End.X, and SRv6 MSD types
- Prefix NLRI: SRv6 Locator
- SRv6 SID NLRI: SRv6 Endpoint behaviour TLV

Topology

Figure 37. BGP-LS with SRv6 ospfv3



Note: You must ensure that prefix SIDs are unique globally.

Configurations

R1 Configuration

The following are the step-by-step configurations on the R1 router.

R1#configure terminal	Enter configure mode.
R1(config)#segment-routing	Enable Segment Routing
R1(config-sr)#srv6	Segment Routing over IPv6 data-plane
R1(config-srv6)#locators	Configure SRv6 locators
R1(config-srv6-loc)#locator IPI	Configure SRv6 locator and name of the Locator
R1(config-srv6-loc-conf)# prefix 1100::/96	prefix for locator ipv6 address
R1(config-srv6-loc-conf)#exit-locator	Exit from srv6 locator mode
R1(config-srv6-loc)#exit-locators	Exit from srv6 locators configuration mode
R1(config-srv6)#exit-srv6	Exit from srv6 configuration mode
R1(config-sr)# commit	Commit the candidate configuration to the running configuration
R1(config-sr)#exit	Exit from segment routing
R1(config)#interface lo	Enter interface mode.
R1(config-if)# ip address 11.11.11.11/32 secondary	Configure the IP address of the interface.
R1(config-if)# ipv6 address 1111::1/128	Configure the IPv6 address of the interface
R1(config-if)#prefix-sid index 1111 no-php	Configure prefix sid index value with no-php.
R1(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
R1(config-if)#exit	Exit interface mode.
R1(config)#commit	Commit the candidate configuration to the running configuration
R1(config)#interface ce2	Enter interface mode.
R1(config-if)#ipv6 address 1000::1/64	Configure the IPv6 address of the interface.
R1(config-if)#ipv6 ospf network point-to-point instance-id 0	Configure ospfv3 network as point to point instance id as 0.
R1(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
R1(config-if)#exit	Exit interface mode.
R1(config)#commit	Commit the candidate configuration to the running configuration
R1(config)#router ipv6 ospf 1	Configure ospf instance process
R1(config-router)#router-id 11.11.11.11	Configure ospf router id
R1(config-router)#segment-routing srv6	Configure segment-routing srv6
R1(config-router-srv6)#srv6-locator IPI	Configure srv6 locator name
R1(config-router-srv6)#exit-srv6	Exit from segment routing srv6
R1(config-router)#commit	Commit the candidate configuration to the running configuration
R1(config-router)#exit	Exit from router mode

R2 Configuration

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Enter configure mode.
R2(config)#segment-routing	Enable Segment Routing
R2(config-sr)#srv6	Segment Routing over IPv6 data-plane
R2(config-srv6)#locators	Configure SRv6 locators
R2(config-srv6-loc)#locator IPI	Configure SRv6 locator and name of the Locator
R2(config-srv6-loc-conf)# prefix 2200::/96	prefix for locator ipv6 address
R2(config-srv6-loc-conf)#exit-locator	Exit from srv6 locator mode
R2(config-srv6-loc)#exit-locators	Exit from srv6 locators configuration mode
R2(config-srv6)#exit	Exit from srv6 configuration mode
R2(config)# commit	Commit the candidate configuration to the running configuration
R2(config)#interface lo	Enter interface mode.
R2(config-if)# ip address 22.22.22.22/32 secondary	Configure the IP address of the interface.
R2(config-if)# ipv6 address 2222::1/128	Configure the IPv6 address of the interface
R2(config-if)#prefix-sid index 2222 no-php	Configure prefix sid index value with no-php.
R2(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
R2(config-if)#exit	Exit interface mode.
R2(config)#commit	Commit the candidate configuration to the running configuration
R2(config)#interface ce0	Enter interface mode.
R2(config-if)# ipv6 address 2000::2/64	Configure the IPv6 address of the interface.
R2(config-if)#ipv6 ospf network point-to-point instance-id 0	Configure ospfv3 network as point to point instance id as 0.
R2(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
R2(config-if)#exit	Exit interface mode.
R2(config)#commit	Commit the candidate configuration to the running configuration
R2(config)#interface cel3	Enter interface mode.
R2(config-if)# ipv6 address 1000::2/64	Configure the IPv6 address of the interface.
R2(config-if)#ipv6 ospf network point-to-point instance-id 0	Configure ospfv3 network as point to point instance id as 0.
R2(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.

R2 (config-if) #exit	Exit interface mode.
R2 (config) #commit	Commit the candidate configuration to the running configuration
R2 (config) #router ipv6 ospf 1	Configure ospf instance process
R2 (config-router) # router-id 22.22.22.22	Configure ospf router id
R2 (config-router) #distribute bgp-ls	Configure Link State distribution to BGP
R2 (config-router) # segment-routing srv6	Configure segment routing srv6
R2 (config-router-srv6) # srv6-locator IPI	Configure srv6 locator name
R2 (config-router-srv6) # exit-srv6	Exit from srv6
R2 (config-router) #commit	Commit the candidate configuration to the running configuration
R2 (config-router) #exit	Exit from router mode
R2 (config) #router bgp 200	Configure bgp AS number
R2 (config-router) #neighbor 2000::1 remote-as 300	Configure neighbour AS number of BGP neighbor
R2 (config-router) #address-family link-state link-state	Configure address family link state link state
R2 (config-router) #neighbor 2000::1 activate	
R2 (config-router-af) #exit-address-family	Exit from Address Family configuration mode
R2 (config) #commit	Commit the candidate configuration to the running configuration
R2 (config) #end	End from EXEC mode

R3 Configuration

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Enter configure mode.
R3 (config) #segment-routing	Enable Segment Routing
R3 (config-sr) #srv6	Segment Routing over IPv6 data-plane
R3 (config-srv6) #locators	Configure SRv6 locators
R3 (config-srv6-loc) #locator OcNOS	Configure SRv6 locator and name of the Locator
R3 (config-srv6-loc-conf) # prefix cafe:1:2:a11::/64	prefix for locator ipv6 address
R3 (config-srv6-loc-conf) #exit-locator	Exit from srv6 locator mode
R3 (config-srv6-loc) #exit-locators	Exit from srv6 locators configuration mode

R3(config-srv6)#exit-srv6	Exit from srv6 configuration mode
R3(config-sr)# commit	Commit the candidate configuration to the running configuration
R3(config-sr)#exit	Exit from segment routing
R3(config)#interface lo	Enter interface mode.
R3(config-if)#ip address 44.44.44.44/32 secondary	Configure the IP address of the interface.
R3(config-if)#ipv6 address 4444::1/128	Configure the IPv6 address of the interface.
R3(config-if)#prefix-sid index 4444 no-php	Configure prefix sid index value with no php.
R3(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
R3(config-if)#exit	Exit interface mode.
R3(config)#commit	Commit the candidate configuration to the running configuration
R3(config)#interface ce9	Enter interface mode.
R3(config-if)# ipv6 address 3000::1/64	Configure the IPv6 address of the interface.
R3(config-if)#ipv6 ospf network point-to-point instance-id 0	Configure ospfv3 network as point to point instance id as 0.
R3(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
R3(config-if)#exit	Exit interface mode.
R3(config)#commit	Commit the candidate configuration to the running configuration
R3(config)#router ipv6 ospf 1	Configure ospf instance process
R3(config-router)#router-id 44.44.44.44	Configure ospf router id
R3(config-router)#distribute bgp-ls	Configure Link State distribution to BGP
R3(config-router)# segment-routing srv6	Configure segment routing srv6
R3(config-router-srv6)#srv6-locator OcNOS	Configure srv6 locator name
R3(config-router-srv6)#exit-srv6	Exit from srv6
R3(config-router)#commit	Commit the candidate configuration to the running configuration
R3(config-router)#exit	Exit from router mode
R3(config)#router bgp 100	Configure bgp AS number
R3(config-router)# neighbor 3000::2 remote-as 300	Configure neighbour AS number of BGP neighbor

R3(config-router)#address-family link-state link-state	Configure address family link state link state
R3(config-router)# neighbor 3000::2 activate	Activated bgp neighbor
R3(config-router-af)#exit-address-family	Exit from Address Family configuration mode
R3(config-router)#commit	Commit the candidate configuration to the running configuration
R3(config-router)#end	End from EXEC mode

Controller Configuration

The following are the step-by-step configurations on the controller.

Controller#configure terminal	Enter configure mode.
Controller(config)#interface lo	Enter interface mode.
Controller(config-if)#ip address 33.33.33.33/32 secondary	Configure the IP address of the interface.
Controller(config-if)#ipv6 address 3333::1/128	Configure the IPv6 address of the interface.
Controller(config-if)#ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
Controller(config-if)#exit	Exit from interface mode.
Controller(config)#commit	Commit the candidate configuration to the running configuration
Controller(config)#interface ce17	Enter interface mode.
troller(config-if)# ipv6 address 3000::2/64	Configure the IPv6 address of the interface.
Controller(config-if)# ipv6 ospf network point-to-point instance-id 0	Configure ospfv3 network as point to point instance id as 0.
Controller(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
Controller(config-if)#exit	Exit from interface mode.
Controller(config)#commit	Commit the candidate configuration to the running configuration
Controller(config)#interface ce20	Enter interface mode.
Controller(config-if)# ipv6 address 2000::1/64	Configure the IPv6 address of the interface.
Controller(config-if)# ipv6 ospf network point-to-point instance-id 0	Configure ospfv3 network as point to point instance id as 0.
Controller(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Configure ospf area id process the tag instance id as 0.
Controller(config-if)#exit	Exit from interface mode.
Controller(config)#commit	Commit the candidate configuration to the running

	configuration
Controller(config)#router ipv6 ospf 1	Configure ospf instance process
Controller(config-router)# router-id 33.33.33.33	Configure ospf router id
Controller(config-router)# distribute bgp-ls	Configure Link State distribution to BGP
Controller(config-router)#exit	Exit from interface mode.
Controller(config)#commit	Commit the candidate configuration to the running configuration
Controller(config)#router bgp 300	Configure bgp AS number
Controller(config-router)# bgp router-id 33.33.33.33	Configure bgp router id
Controller(config-router)# neighbor 2000::2 remote-as 200	Configure neighbour AS number of BGP neighbour
Controller(config-router)# neighbor 3000::1 remote-as 100	Configure neighbour AS number of BGP neighbour
Controller(config-router)# address-family link-state link-state	Configure address family link state link state
Controller(config-router-af)# neighbor 2000::2 activate	Activated bgp neighbour
Controller(config-router-af)# neighbor 3000::1 activate	
Controller(config-router-af)# exit-address-family	Exit from Address Family configuration mode
Controller(config-router)#commit	Commit the candidate configuration to the running configuration
Controller(config-router)#end	End from EXEC mode

Validation

PE1

BGP-LS NLRIs

Validation on BGP-LS NLRIs

```

R2#show bgp link-state link-state
BGP router identifier 22.22.22.22, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, S SRv6 SID
               I Identifier N local node, R remote node, L link P prefix, S SID
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, O6 OSPFv3, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID, s SID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]]/216
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]]/216
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]]/216
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]]/216

```



```

[V] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]]/216
[V] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]]/216
[V] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33]]/216
[V] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]]/216
e [V] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]]/216
e [V] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]]/216
e [V] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33]]/216
e [V] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]]/216
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]]
[R[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]]/280
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]]
[R[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]]/280
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::eac5:7aff:feba:f15] [nfe80::e201:a6ff:fea5:f16]]/536
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r22.22.22.22]]
[L[ife80::e201:a6ff:fea5:f16] [nfe80::eac5:7aff:feba:f15]]/536
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r44.44.44.44]]
[L[ife80::e201:a6ff:fea5:f13] [nfe80::e201:a6ff:febb:110b]]/536
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::e201:a6ff:febb:110b] [nfe80::e201:a6ff:fea5:f13]]/536
[E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r22.22.22.22]]
[L[ife80::eac5:7aff:fe78:c909] [nfe80::eac5:7aff:feba:f22]]/536
[E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r11.11.11.11]]
[L[ife80::eac5:7aff:feba:f22] [nfe80::eac5:7aff:fe78:c909]]/536
[E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::eac5:7aff:feba:f15] [nfe80::e201:a6ff:fea5:f16]]/536
[E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r22.22.22.22]]
[L[ife80::e201:a6ff:fea5:f16] [nfe80::eac5:7aff:feba:f15]]/536
[E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r44.44.44.44]]/280
[E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r33.33.33.33]]/280
e [E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r22.22.22.22]]/280
e [E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r11.11.11.11]]/280
e [E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r33.33.33.33]]/280
e [E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r22.22.22.22]]/280
e [E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r44.44.44.44]]
[L[ife80::e201:a6ff:fea5:f13] [nfe80::e201:a6ff:febb:110b]]/536
e [E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::e201:a6ff:febb:110b] [nfe80::e201:a6ff:fea5:f13]]/536
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p1000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p1100::/96]]/328
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1]
[p1111::1/128]]/360
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p1000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p2000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p2200::/96]]/328
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1]
[p2222::1/128]]/360
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p2000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p3000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1]
[p3333::1/128]]/360
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1] [p3000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1]]

```

[illegible]

```

e [S] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::801:0/128]]/352
e [S] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002]
[s2200::1001:0/128]]/352
e [S] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002]
[s2200::2001:0/128]]/352
e [S] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[safe:1:2:a11:801::/128]]/352
e [S] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[safe:1:2:a11:1001::/128]]/352
e [S] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[safe:1:2:a11:2001::/128]]/352
NLRIs, Total: 96, Node: 12, Link: 18, Prefix: 39, SRv6-SID: 27
R2#
R2#show bgp link-state link-state count
-----
Total   NLRIs   : 96
Node    NLRIs   : 12
Link    NLRIs   : 18
Prefix  NLRIs   : 39
SRV6 SID NLRIs : 27
-----
R2#show bgp link-state link-state self-originate
BGP router identifier 22.22.22.22, local AS number 200
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, S SRv6 SID
               I Identifier N local node, R remote node, L link P prefix, S SID
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, O6 OSPFv3, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID, s SID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
[V] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]]/216
[V] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]]/216
[V] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33]]/216
[V] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]]/216
[E] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11] [R[c200] [b22.22.22.22]
[a0.0.0.0] [r22.22.22.22]] [L[ife80::5e07:58ff:feab:3e06] [nfe80::5e17:83ff:fe9a:f
0c7]]/536
[E] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22] [R[c200] [b22.22.22.22]
[a0.0.0.0] [r11.11.11.11]] [L[ife80::5e17:83ff:fe9a:f0c7] [nfe80::5e07:58ff:feab:3
e06]]/536
[E] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22] [R[c200] [b22.22.22.22]
[a0.0.0.0] [r33.33.33.33]] [L[ife80::5e17:83ff:fe9a:f0da] [nfe80::d6dc:85ff:fede:7
826]]/536
[E] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33] [R[c200] [b22.22.22.22]
[a0.0.0.0] [r22.22.22.22]] [L[ife80::d6dc:85ff:fede:7826] [nfe80::5e17:83ff:fe9a:f
0da]]/536
[E] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33] [R[c200] [b22.22.22.22]
[a0.0.0.0] [r44.44.44.44]] [L[i::c0:dd52:b341:7f00] [nc0:e052:b341:7f00:80:5469:10
0:0]]/536
[E] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44] [R[c200] [b22.22.22.22]
[a0.0.0.0] [r33.33.33.33]] [L[i::80:e452:b341:7f00] [n40:b552:b341:7f00:80:5469:10
0:0]]/536
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p10
00::/64]]/296
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p11
00::/96]]/328
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p11
11::1/128]]/360
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p10
00::/64]]/296
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p20
00::/64]]/296
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p22
00::/96]]/328
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p22
22::1/128]]/360

```

```
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p20
00::/64]]/296
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p30
00::/64]]/296
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p33
33::1/128]]/360
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1] [p30
00::/64]]/296
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1] [pca
fe:1:2:a11::/64]]/296
[T] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1] [p44
44::1/128]]/360
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::8
01:0/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::1
001:0/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::2
001:0/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::8
01:0/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::1
001:0/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::2
001:0/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002] [scafe:1:
2:a11:801::/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002] [scafe:1:
2:a11:1001::/128]]/352
[S] [O6] [I0x1] [N[c200] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002] [scafe:1:
2:a11:2001::/128]]/352
NLRIs, Total: 32, Node: 4, Link: 6, Prefix: 13, SRv6-SID: 9
R2#
```

Node-NLRI

Validation on Node-NLRI

```
R2#sh bgp link-state link-state [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]]/216
BGP routing table entry for [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]]/216
Local
  Received from 2000::1
  Link State:
  SR Algorithm: 0
  SRv6 Capability is enabled - flags 0
  Maximum SID Depth :
    SRH maximum segments left (41) : 4
    SRH maximum end pop (42) : 4
    SRH maximum H.encaps (44) : 4
    SRH maximum decapsulation sids (45) : 4
  Node flag bits: O:0 T:0 B:0 E:0
  Local TE Router-ID:11.11.11.11
R2#
```

Link-NLRI

Validation on Link-NLRI

```
R2#show bgp link-state link-state [E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11] [R
[c300] [b33.33.33.33] [a0.0.0.0]
[r22.22.22.22]]/280
BGP routing table entry for [E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11] [R[c300]
[b33.33.33.33] [a0.0.0.0]
[r22.22.22.22]]/280
Local
  Received from 2000::1
```

```

Link State:
Local Router ID: 11.11.11.11, Remote Router ID: 22.22.22.22
IGP metric 1    SRv6 End.X
  SRv6 End.X Endpoint behavior value: 6 - End.X with PSP
  SRv6 End.X Endpoint Flags: 0
  SRv6 End.X Endpoint Algorithm: 0
  SRv6 End.X Endpoint Weight: 0
  SRv6 End.X SRv6 SID: 1100::2002:0
R2#

```

Prefix-NLRI

Validation on Prefix-NLRI

```

R2#sh bgp link-state link-state [T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P
[t0x0002][0x1][p1100::/96]]/328
BGP routing table entry for [T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P
[t0x0002][0x1][p1100::/96]]/328
Local
  Received from 2000::1
  Link State:
    Metric: 1    SRv6 Locator Flags: 0    SRv6 Locator Algorithm: 0    SRv6 Locator Metric: 0
R3#

```

SRv6

Validation on SRv6

```

R2#sh bgp link-state link-state [S][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r11.11.11.11]][S
[t0x0002][s1100::2001:0/128]]/352
BGP routing table entry for [S][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r11.11.11.11]][S
[t0x0002][s1100::2001:0/128]]/352
Local
  Received from IGP
  Link State:
    SRv6 Endpoint behavior:
    SRv6 Locator Endpoint :2 - End with PSP    SRv6 flags :0    SRv6 Algorithm :0
R2#

```

R3

Validation on R3

```

R3#show ipv6 ospf neighbor

Total number of full neighbors: 1
OSPFv3 Process (1)
Neighbor ID    Pri   State           Dead Time   Interface   Instance ID
33.33.33.33    1     Full/ -         00:00:37   ce9         0

R3#show ipv6 ospf database

                OSPFv3 Router with ID (44.44.44.44) (Process 1)

                Link-LSA (Interface lo)

Link State ID  ADV Router    Age      Seq#          CkSum  Prefix
0.0.0.1        44.44.44.44   266      0x80000002   0x0d9e  2

                Link-LSA (Interface ce5)

Link State ID  ADV Router    Age      Seq#          CkSum  Prefix
0.0.39.22     44.44.44.44   261      0x80000003   0xcelc  1

                Link-LSA (Interface ce9)

```

Link State ID	ADV Router	Age	Seq#	CkSum	Prefix
0.0.39.34	33.33.33.33	255	0x80000003	0xaa4c	1
0.0.39.26	44.44.44.44	254	0x80000003	0xe2df	1

Router-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum	Link
0.0.0.0	11.11.11.11	316	0x80000005	0xb910	1
0.0.0.0	22.22.22.22	242	0x80000007	0xd0db	2
0.0.0.0	33.33.33.33	235	0x80000005	0xaf9c	2
0.0.0.0	44.44.44.44	241	0x80000004	0xf843	1

Intra-Area-Prefix-LSA (Area 0.0.0.0)

Link State ID	ADV Router	Age	Seq#	CkSum	Prefix	Reference
0.0.0.1	11.11.11.11	311	0x80000006	0xe9b1	2	Router-LSA
0.0.0.1	22.22.22.22	237	0x80000008	0xdc3	3	Router-LSA
0.0.0.1	33.33.33.33	230	0x80000006	0x3cdb	3	Router-LSA
0.0.0.1	44.44.44.44	236	0x80000005	0x03ab	3	Router-LSA

R3#sh ipv6 ospf database router

OSPFv3 Router with ID (44.44.44.44) (Process 1)

Router-LSA (Area 0.0.0.0)

LS age: 326
 LS Type: Router-LSA
 Link State ID: 0.0.0.0
 Advertising Router: 11.11.11.11
 LS Seq Number: 0x80000005
 Checksum: 0xB910
 Length: 40
 Flags: 0x00 (-|-|-|-)
 Options: 0x00133 (AF|*|*|DC|R|-|-|E|V6)

Link connected to: another Router (point-to-point)
 Metric: 1
 Interface ID: 10009
 Neighbor Interface ID: 10053
 Neighbor Router ID: 22.22.22.22

LS age: 252
 LS Type: Router-LSA
 Link State ID: 0.0.0.0
 Advertising Router: 22.22.22.22
 LS Seq Number: 0x80000007
 Checksum: 0xD0DB
 Length: 56
 Flags: 0x00 (-|-|-|-)
 Options: 0x00133 (AF|*|*|DC|R|-|-|E|V6)

Link connected to: another Router (point-to-point)
 Metric: 1
 Interface ID: 10053
 Neighbor Interface ID: 10009
 Neighbor Router ID: 11.11.11.11

Link connected to: another Router (point-to-point)
 Metric: 1
 Interface ID: 10001
 Neighbor Interface ID: 10021
 Neighbor Router ID: 33.33.33.33

LS age: 244

```
LS Type: Router-LSA
Link State ID: 0.0.0.0
Advertising Router: 33.33.33.33
LS Seq Number: 0x80000005
Checksum: 0xAF9C
Length: 56
Flags: 0x00 (-|-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)

Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10018
Neighbor Interface ID: 10010
Neighbor Router ID: 44.44.44.44

Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10021
Neighbor Interface ID: 10001
Neighbor Router ID: 22.22.22.22

LS age: 250
LS Type: Router-LSA
Link State ID: 0.0.0.0
Advertising Router: 44.44.44.44
LS Seq Number: 0x80000004
Checksum: 0xF843
Length: 40
Flags: 0x00 (-|-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)

Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10010
Neighbor Interface ID: 10018
Neighbor Router ID: 33.33.33.33

R3#sh ipv6 ospf database router self-originate

        OSPFv3 Router with ID (44.44.44.44) (Process 1)

                Router-LSA (Area 0.0.0.0)

LS age: 256
LS Type: Router-LSA
Link State ID: 0.0.0.0
Advertising Router: 44.44.44.44
LS Seq Number: 0x80000004
Checksum: 0xF843
Length: 40
Flags: 0x00 (-|-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)

Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10010
Neighbor Interface ID: 10018
Neighbor Router ID: 33.33.33.33

BGP Neighborhood

R3#show bgp neighbors
BGP neighbor is 3000::2, remote AS 300, local AS 100, external link
BGP version 4, local router ID 44.44.44.44, remote router ID 33.33.33.33
BGP state = Established, up for 00:35:11
Last read 00:00:23, hold time is 90, keepalive interval is 30 seconds
Neighbor capabilities:
```

```

Route refresh: advertised and received (old and new)
Address family Link-State Link-State: advertised and received
Received 105 messages, 0 notifications, 0 in queue
Sent 95 messages, 0 notifications, 0 in queue
Route refresh request: received 0, sent 0
Minimum time between advertisement runs is 30 seconds
For address family: Link-State Link-State
BGP table version 6, neighbor version 6
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
42 accepted prefixes
21 announced prefixes

Connections established 1; dropped 0
Local host: 3000::1, Local port: 179
Foreign host: 3000::2, Foreign port: 37124
NextHop: 44.44.44.44
NextHop global: 3000::1
NextHop local: fe80::e201:a6ff:febb:110b
BGP connection: shared network

R3#show bgp link-state link-state summary
BGP router identifier 44.44.44.44, local AS number 100
BGP table version is 7
2 BGP AS-PATH entries
0 BGP community entries

Neighbor      V   AS      MsgRcv   MsgSen   TblVer   InQ     OutQ     Up/Down   Sta
te/PfxRcd
3000::2       4     300       58       38        7        0        0        00:08:32   64

Total number of neighbors 1

Total number of Established sessions 1
R3#

```

NLRI

Validation on NLRI

```

R3#show bgp link-state link-state
BGP router identifier 44.44.44.44, local AS number 200
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, S SRv6 SID
               I Identifier N local node, R remote node, L link P prefix, S SID
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, O6 OSPFv3, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID, s SID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]]/216
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]]/216
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]]/216
e [V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]]/216
[V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]]/216
[V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]]/216
[V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33]]/216
[V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]]/216
e [E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r22.22.22.22]]/280
e [E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r11.11.11.11]]/280

```



```

e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::eac5:7aff:feba:f15]
[nfe80::e201:a6ff:fea5:f16]]/536
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r22.22.22.22]]
[L[ife80::e201:a6ff:fea5:f16]
[nfe80::eac5:7aff:feba:f15]]/536
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r44.44.44.44]]
[L[ife80::e201:a6ff:fea5:f13]
[nfe80::e201:a6ff:febb:110b]]/536
e [E] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::e201:a6ff:febb:110b]
[nfe80::e201:a6ff:fea5:f13]]/536
e [E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r22.22.22.22]]
[L[ife80::eac5:7aff:fe78:c909]
[nfe80::eac5:7aff:feba:f22]]/536
e [E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r11.11.11.11]]
[L[ife80::eac5:7aff:feba:f22]
[nfe80::eac5:7aff:fe78:c909]]/536
e [E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::eac5:7aff:feba:f15]
[nfe80::e201:a6ff:fea5:f16]]/536
e [E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r22.22.22.22]]
[L[ife80::e201:a6ff:fea5:f16]
[nfe80::eac5:7aff:feba:f15]]/536
e [E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r44.44.44.44]]/280
e [E] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44] [R[c100] [b22.22.22.22] [a0.0.0.0]
[r33.33.33.33]]/280
[E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r22.22.22.22]]/280
[E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r11.11.11.11]]/280
[E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r33.33.33.33]]/280
[E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r22.22.22.22]]/280
[E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r44.44.44.44]]
[L[ife80::e201:a6ff:fea5:f13] [nfe80::e201:a6ff:febb:110b]]/536
[E] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44] [R[c200] [b44.44.44.44] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::e201:a6ff:febb:110b] [nfe80::e201:a6ff:fea5:f13]]/536
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p1000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p1100::/96]]/328
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1]
[p1111::1/128]]/360
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p1000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p2000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p2200::/96]]/328
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1]
[p2222::1/128]]/360
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p2000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p3000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1]
[p3333::1/128]]/360
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1] [p3000::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1]
[pcafe:l:2:a11::/64]]/296
e [T] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1]
[p4444::1/128]]/360

```

[illegible]

```

[S][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r22.22.22.22]][S[t0x0002][s2200::1001:0/128]]/352
[S][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r22.22.22.22]][S[t0x0002][s2200::2001:0/128]]/352
[S][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r44.44.44.44]][S[t0x0002]
[scafe:1:2:all:801::/128]]/352
[S][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r44.44.44.44]][S[t0x0002]
[scafe:1:2:all:1001::/128]]/352
[S][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r44.44.44.44]][S[t0x0002]
[scafe:1:2:all:2001::/128]]/352
NLRIs, Total: 96, Node: 12, Link: 18, Prefix: 39, SRv6-SID: 27
R3#
R3#show bgp link-state link-state count
-----
Total   NLRIs    : 96
Node    NLRIs    : 12
Link    NLRIs    : 18
Prefix  NLRIs    : 39
SRV6 SID NLRIs  : 27
-----

R3#show bgp link-state link-state self-originate
BGP router identifier 44.44.44.44, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, S SRv6 SID
I Identifier N local node, R remote node, L link P prefix, S SID
N local node, R remote node, L link, P prefix
L1/L2 ISIS level-1/level-2, O OSPF, O6 OSPFv3, a area-ID,
c confed-ID/ASN, b bgp-identifier, r router-ID, s SID,
i if-address, n nbr-address, o OSPF Route-type,
p IP-prefix, d designated router address, s ISO-ID
[V][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11]]/216
[V][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]]/216
[V][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r33.33.33.33]]/216
[V][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44]]/216
[E][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11][R[c100][b44.44.44.44]
[a0.0.0.0][r22.22.22.22]][L[i::80:e132:951f:7f00][nc0:c832:951f:7f00:80:d4b7:20
0:0]]/536
[E][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22][R[c100][b44.44.44.44]
[a0.0.0.0][r11.11.11.11]][L[i::c0:e332:951f:7f00][n80:c632:951f:7f00:80:d4b7:20
0:0]]/536
[E][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22][R[c100][b44.44.44.44]
[a0.0.0.0][r33.33.33.33]][L[i::40:ca32:951f:7f00][n80:99fe:8f1f:7f00:80:d4b7:20
0:0]]/536
[E][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r33.33.33.33][R[c100][b44.44.44.44]
[a0.0.0.0][r22.22.22.22]][L[i::c0:d132:951f:7f00][n40:be32:951f:7f00:80:d4b7:20
0:0]]/536
[E][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r33.33.33.33][R[c100][b44.44.44.44]
[a0.0.0.0][r44.44.44.44]][L[ife80::d6dc:85ff:fede:782a][nfe80::5e07:58ff:fe28:b
469]]/536
[E][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44][R[c100][b44.44.44.44]
[a0.0.0.0][r33.33.33.33]][L[ife80::5e07:58ff:fe28:b469][nfe80::d6dc:85ff:fede:7
82a]]/536
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p10
00::/64]]/296
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p11
00::/96]]/328
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p11
11::1/128]]/360
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p10
00::/64]]/296
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p20
00::/64]]/296
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p22
00::/96]]/328
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p22
22::1/128]]/360
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p20
00::/64]]/296

```

```

[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p30
00::/64]]/296
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p33
33::1/128]]/360
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1][p30
00::/64]]/296
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1][pca
fe:1:2:a11::/64]]/296
[T][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1][p44
44::1/128]]/360
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11]][S[t0x0002][s1100::8
01:0/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11]][S[t0x0002][s1100::1
001:0/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r11.11.11.11]][S[t0x0002][s1100::2
001:0/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]][S[t0x0002][s2200::8
01:0/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]][S[t0x0002][s2200::1
001:0/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r22.22.22.22]][S[t0x0002][s2200::2
001:0/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44]][S[t0x0002][scafe:1:
2:a11:801::/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44]][S[t0x0002][scafe:1:
2:a11:1001::/128]]/352
[S][O6][I0x1][N[c100][b44.44.44.44][a0.0.0.0][r44.44.44.44]][S[t0x0002][scafe:1:
2:a11:2001::/128]]/352
NLRI's, Total: 32, Node: 4, Link: 6, Prefix: 13, SRv6-SID: 9
R3#NODE NLRI

R3#sh bgp link-state link-state [V][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0]
[r22.22.22.22]]/216
BGP routing table entry for [V][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22]]/216
Local
  Received from 3000::2
  Link State:
  SR Algorithm: 0
  SRv6 Capability is enabled - flags 0
  Maximum SID Depth :
    SRH maximum segments left (41) : 4
    SRH maximum end pop (42) : 4
    SRH maximum H.encaps (44) : 4
    SRH maximum decapsulation sids (45) : 4
  Node flag bits: O:0 T:0 B:0 E:0
  Local TE Router-ID:22.22.22.22
R3#
LINK NLRI

R3#sh bgp link-state link-state [E][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22][R
[c300][b33.33.33.33][a0.0.0.0]
[r11.11.11.11]]/280
BGP routing table entry for [E][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22][R[c300]
[b33.33.33.33][a0.0.0.0]
[r11.11.11.11]]/280
Local
  Received from 3000::2
  Link State:
  Local Router ID: 22.22.22.22, Remote Router ID: 11.11.11.11
  IGP metric 1    SRv6 End.X
    SRv6 End.X Endpoint behavior value: 6 - End.X with PSP
    SRv6 End.X Endpoint Flags: 0
    SRv6 End.X Endpoint Algorithm: 0
    SRv6 End.X Endpoint Weight: 0
    SRv6 End.X SRv6 SID: 2200::2002:0
R3#
Prefix NLRI

```

```

R3#sh bgp link-state link-state [T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P
[t0x0002][0x1][p1100::/96]]/328
BGP routing table entry for [T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P
[t0x0002][0x1][p1100::/96]]/328
Local
  Received from 3000::2
  Link State:
  Metric: 1      SRv6 Locator Flags: 0      SRv6 Locator Algorithm: 0      SRv6 Locator Metric: 0
R3#
SRv6 NLRI

R3#show bgp link-state link-state [S][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r11.11.11.11]][S
[t0x0002][s1100::801:0/128]]/352
BGP routing table entry for [S][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r11.11.11.11]][S
[t0x0002][s1100::801:0/128]]/352
Local
  Received from IGP
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :28 - End with USD      SRv6 flags :0      SRv6 Algorithm :0
R3#

```

Controller

Validation on Controller

```

Controller#show bgp neighbors
BGP neighbor is 2000::2, remote AS 200, local AS 300, external link
  BGP version 4, local router ID 33.33.33.33, remote router ID 22.22.22.22
  BGP state = Established, up for 00:03:32
  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 Link-State Link-State: advertised and received
  Received 18 messages, 0 notifications, 0 in queue
  Sent 30 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
For address family: Link-State Link-State
  BGP table version 6, neighbor version 6
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  21 accepted prefixes
  42 announced prefixes

  Connections established 1; dropped 0
  Local host: 2000::1, Local port: 179
  Foreign host: 2000::2, Foreign port: 56356
  Nexthop: 33.33.33.33
  Nexthop global: 2000::1
  Nexthop local: fe80::e201:a6ff:fea5:f16
  BGP connection: shared network

BGP neighbor is 3000::1, remote AS 100, local AS 300, external link
  BGP version 4, local router ID 33.33.33.33, remote router ID 44.44.44.44
  BGP state = Established, up for 00:03:32
  Last read 00:00:09, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family Link-State Link-State: advertised and received
  Received 18 messages, 0 notifications, 0 in queue
  Sent 29 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds

```

```

For address family: Link-State Link-State
BGP table version 6, neighbor version 6
Index 2, Offset 0, Mask 0x4
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
21 accepted prefixes
42 announced prefixes

```

```

Connections established 1; dropped 0
Local host: 3000::2, Local port: 33796
Foreign host: 3000::1, Foreign port: 179
Nexthop: 33.33.33.33
Nexthop global: 3000::2
Nexthop local: fe80::e201:a6ff:fea5:f13
BGP connection: shared network

```

BGP-LS NLRIs

Validation on BGP-LS NLRIs

```

Controller#show bgp link-state link-state summary
BGP router identifier 33.33.33.33, local AS number 300
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
2000::2           4    100    53       61      6        0      0   00:11:56      32
3000::1           4    200    46       66      6        0      0   00:11:56      32

Total number of neighbors 2

Total number of Established sessions 2
Controller#
Controller#show bgp link-state link-state
BGP router identifier 33.33.33.33, local AS number 300
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, S SRv6 SID
               I Identifier N local node, R remote node, L link P prefix, S SID
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, O6 OSPFv3, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID, s SID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
[V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]]/216
[V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]]/216
[V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33]]/216
[V] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r33.33.33.33]]/216
e [V] [O6] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]]/216
e [V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]]/216
e [V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]]/216
e [V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33]]/216
e [V] [O6] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]]/216
[E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r22.22.22.22]]/280
[E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r11.11.11.11]]/280
[E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r33.33.33.33]]
[L[ife80::eac5:7aff:feba:f15] [nfe80::e201:a6ff:fea5:f16]]/536
[E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33] [R[c300] [b33.33.33.33] [a0.0.0.0]
[r22.22.22.22]]
[L[ife80::e201:a6ff:fea5:f16] [nfe80::eac5:7aff:feba:f15]]/536
[E] [O6] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r33.33.33.33] [R[c300] [b33.33.33.33] [a0.0.0.0]

```

```

[r44.44.44.44]]
[L[ife80::e201:a6ff:fea5:f13][nfe80::e201:a6ff:febb:110b]]/536
[E][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r44.44.44.44][R[c300][b33.33.33.33][a0.0.0.0]
[r33.33.33.33]]
[L[ife80::e201:a6ff:febb:110b][nfe80::e201:a6ff:fea5:f13]]/536
e [E][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r11.11.11.11][R[c100][b22.22.22.22][a0.0.0.0]
[r22.22.22.22]]
[L[ife80::eac5:7aff:fe78:c909][nfe80::eac5:7aff:feba:f22]]/536
e [E][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r22.22.22.22][R[c100][b22.22.22.22][a0.0.0.0]
[r11.11.11.11]]
[L[ife80::eac5:7aff:feba:f22][nfe80::eac5:7aff:fe78:c909]]/536
e [E][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r22.22.22.22][R[c100][b22.22.22.22][a0.0.0.0]
[r33.33.33.33]]
[L[ife80::eac5:7aff:feba:f15][nfe80::e201:a6ff:fea5:f16]]/536
e [E][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r33.33.33.33][R[c100][b22.22.22.22][a0.0.0.0]
[r22.22.22.22]]
[L[ife80::e201:a6ff:fea5:f16][nfe80::eac5:7aff:feba:f15]]/536
e [E][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r33.33.33.33][R[c100][b22.22.22.22][a0.0.0.0]
[r44.44.44.44]]/280
e [E][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r44.44.44.44][R[c100][b22.22.22.22][a0.0.0.0]
[r33.33.33.33]]/280
e [E][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r11.11.11.11][R[c200][b44.44.44.44][a0.0.0.0]
[r22.22.22.22]]/280
e [E][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r22.22.22.22][R[c200][b44.44.44.44][a0.0.0.0]
[r11.11.11.11]]/280
e [E][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r22.22.22.22][R[c200][b44.44.44.44][a0.0.0.0]
[r33.33.33.33]]/280
e [E][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r33.33.33.33][R[c200][b44.44.44.44][a0.0.0.0]
[r22.22.22.22]]/280
e [E][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r33.33.33.33][R[c200][b44.44.44.44][a0.0.0.0]
[r44.44.44.44]]
[L[ife80::e201:a6ff:fea5:f13][nfe80::e201:a6ff:febb:110b]]/536
e [E][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r44.44.44.44][R[c200][b44.44.44.44][a0.0.0.0]
[r33.33.33.33]]
[L[ife80::e201:a6ff:febb:110b][nfe80::e201:a6ff:fea5:f13]]/536
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p1000::/64]]/296
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p1100::/96]]/328
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p1111::1/128]]/360
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p1000::/64]]/296
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p2000::/64]]/296
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p2200::/96]]/328
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p2222::1/128]]/360
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p2000::/64]]/296
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p3000::/64]]/296
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p3333::1/128]]/360
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1][p3000::/64]]/296
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1]]
[pcafe:1:2:a11::/64]]/296
[T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1][p4444::1/128]]/360
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p1000::/64]]/296
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p1100::/96]]/328
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1]
[p1111::1/128]]/360
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p1000::/64]]/296
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p2000::/64]]/296
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1][p2200::/96]]/328
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r22.22.22.22]][P[t0x0002][0x1]
[p2222::1/128]]/360
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p2000::/64]]/296
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1][p3000::/64]]/296
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r33.33.33.33]][P[t0x0002][0x1]
[p3333::1/128]]/360
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1][p3000::/64]]/296
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1]
[pcafe:1:2:a11::/64]]/296
e [T][O6][I0x1][N[c100][b22.22.22.22][a0.0.0.0][r44.44.44.44]][P[t0x0002][0x1]
[p4444::1/128]]/360
e [T][O6][I0x1][N[c200][b44.44.44.44][a0.0.0.0][r11.11.11.11]][P[t0x0002][0x1][p1000::/64]]/296

```

```

e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1] [p1100::/96]]/328
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]] [P[t0x0002] [0x1]
[p1111::1/128]]/360
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p1000::/64]]/296
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p2000::/64]]/296
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1] [p2200::/96]]/328
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [P[t0x0002] [0x1]
[p2222::1/128]]/360
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p2000::/64]]/296
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1] [p3000::/64]]/296
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r33.33.33.33]] [P[t0x0002] [0x1]
[p3333::1/128]]/360
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1] [p3000::/64]]/296
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1]
[pcafe:1:2:a11::/64]]/296
e [T] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [P[t0x0002] [0x1]
[p4444::1/128]]/360
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::801:0/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::1001:0/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::2001:0/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::801:0/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::1001:0/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::2001:0/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:801::/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:1001::/128]]/352
[S] [06] [I0x1] [N[c300] [b33.33.33.33] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:2001::/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::801:0/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002]
[s1100::1001:0/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002]
[s1100::2001:0/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::801:0/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002]
[s2200::1001:0/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002]
[s2200::2001:0/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:801::/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:1001::/128]]/352
e [S] [06] [I0x1] [N[c100] [b22.22.22.22] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:2001::/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002] [s1100::801:0/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002]
[s1100::1001:0/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r11.11.11.11]] [S[t0x0002]
[s1100::2001:0/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002] [s2200::801:0/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002]
[s2200::1001:0/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r22.22.22.22]] [S[t0x0002]
[s2200::2001:0/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:801::/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:1001::/128]]/352
e [S] [06] [I0x1] [N[c200] [b44.44.44.44] [a0.0.0.0] [r44.44.44.44]] [S[t0x0002]
[scafe:1:2:a11:2001::/128]]/352
NLRI's, Total: 96, Node: 12, Link: 18, Prefix: 39, SRv6-SID: 27
Controller#
Controller#
Controller#
Controller#
Controller#show bgp link-state link-state count
-----

```



```

Total  NLRIs   : 96
Node   NLRIs   : 12
Link   NLRIs   : 18
Prefix NLRIs   : 39
SRV6 SID NLRIs : 27
-----
Controller#

```

NLRI

Validation for Particular NLRI

NODE NLRI

```

Controller#sh bgp link-state link-state [V][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0]
[r44.44.44.44]]/216
BGP routing table entry for [V][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r44.44.44.44]]/216
Local
  Received from IGP
  Link State:
  SR Algorithm: 0
  SRv6 Capability is enabled - flags 0
  Maximum SID Depth :
    SRH maximum segments left (41) : 4
    SRH maximum end pop (42) : 4
    SRH maximum H.encaps (44) : 4
    SRH maximum decapsulation sids (45) : 4
  Node flag bits: O:0 T:0 B:0 E:0
  Local TE Router-ID:44.44.44.44
Controller#

```

LINK NLRI

```

Controller#sh bgp link-state link-state [E][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0]
[r11.11.11.11][R[c300]
[b33.33.33.33][a0.0.0.0][r22.22.22.22]]/280
BGP routing table entry for [E][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11][R[c300]
[b33.33.33.33][a0.0.0.0][r22.22.22.22]]/280
Local
  Received from IGP
  Link State:
  Local Router ID: 11.11.11.11, Remote Router ID: 22.22.22.22
  IGP metric 1    SRv6 End.X
    SRv6 End.X Endpoint behavior value: 6 - End.X with PSP
    SRv6 End.X Endpoint Flags: 0
    SRv6 End.X Endpoint Algorithm: 0
    SRv6 End.X Endpoint Weight: 0
    SRv6 End.X SRv6 SID: 1100::2002:0
Controller#

```

Prefix NLRI

```

Controller#sh bgp link-state link-state [T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0]
[r11.11.11.11]][P[t0x0002]
[0x1][p1100::/96]]/328
BGP routing table entry for [T][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r11.11.11.11]][P
[t0x0002][0x1][p1100::/96]]/328
Local
  Received from 3000::2
  Link State:
  Metric: 1    SRv6 Locator Flags: 0    SRv6 Locator Algorithm: 0    SRv6 Locator Metric: 0
R3#
SRv6 NLRI

```

```

Controller#show bgp link-state link-state [S][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0]
[r22.22.22.22]][S[t0x0002]
[s2200::801:0/128]]/352
BGP routing table entry for [S][O6][I0x1][N[c300][b33.33.33.33][a0.0.0.0][r22.22.22.22]][S
[t0x0002][s2200::801:0/128]]/352

```

```
Local
  Received from IGP
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :28 - End with USD    SRv6 flags :0    SRv6 Algorithm :0
Controller#
```

SRv6 BGP LS with ISIS Configuration

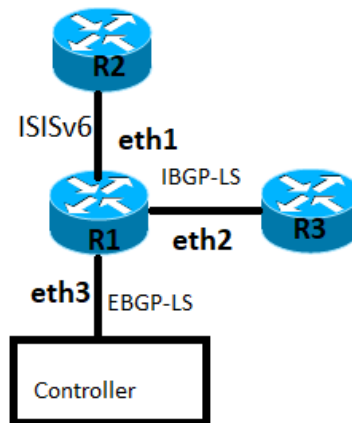
This section contains configurations of SRv6 BGP-LS with ISISv6.

BGP-LS

BGP-LS describes a mechanism by which Link-State (LS) and Traffic Engineering (TE) information from IS-IS can be collected from networks and shared with external components using the BGP. It advertises the SRv6 SID's and other SRv6 information from all the SRv6 capable nodes in the IGP domain when sourced from link-state routing protocols.

Topology

Figure 38. BGP-LS with ISISv6 configuration topology



Configuration

R1

The following are the step-by-step configurations on the R1 router.

R1#configure terminal	Enter configure mode.
R1(config)#interface lo	Enter interface mode.
R1(config-if)#ipv6 address cafe:1:2::11/128	Configure IPv6 address of the loopback interface.
R1(config-if)#ip address 11.11.11.11/32 secondary	Configure ip address on the loopback interface as secondary
R1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.

R1(config-if)#exit	Exit interface mode.
R1(config)#interface eth1	Enter interface mode.
R1(config-if)#ipv6 address 2424::1/64	Configure the IPv6 address of the interface.
R1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config)#interface eth2	Enter interface mode.
R1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#ipv6 address 65::2/64	Configure the IPv6 address of the interface.
R1(config-if)#exit	Exit interface mode
R1(config)#interface eth3	Enter interface mode.
R1(config-if)#ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#ipv6 address 2002::1/64	Configure the IPv6 address of the interface.
R1(config-if)#exit	Exit interface mode
R1(config)#router isis 1	Set the routing process ID as 1
R1(config-router)#is-type level-2	Configure is-type as level-2
R1(config-router)#metric-style wide level-2	Configure wide metric-style
R1(config-router)# net 49.0001.0000.0000.0001.00	Configure Network entity title (NET).
R1(config-router)#mpls traffic-eng ipv6 router-id cafe:1:2::11	Configure Ipv6 router-id
R1(config-router)#mpls traffic-eng level-2	Configure mpls traffic engineering for level-2
R1(config-router)#distribute bgp-ls	Link State distribution to BGP
R1(config-router)# address-family ipv6	Enter Address-family ipv6
R1(config-router-af)# multi-topology level-2	Enable Multi-Topology
R1(config-router-af)#segment-routing srv6	Enable srv6 under ipv6 address-family
R1(config-router-af-srv6)# srv6-locator R1_locator	Name to srv6 locator
R1(config-router-af-srv6)#exit-srv6	Exit srv6 mode
R1(config-router-af)#exit-address-family	Exit address-family ipv6
R1(config-router)#exit	Exit router mode.
R1(config)# router bgp 1000	Configure router BGP in AS 1000
R1(config-router)# neighbor 65::1 remote-as 1000	Configure neighbor in remote-as 1000
R1(config-router)# neighbor 2002::2 remote-as 1	Configure neighbor with remote-as 1
R1(config-router)# address-family link-state link-state	Enter link-state Address family mode
R1(config-router-af)# neighbor 65::1 activate	Activate IBGP-LS neighbor
R1(config-router-af)# neighbor 2002::2 activate	Activate EBGP-LS neighbor

R1(config-router-af)#exit-address-family	Exit from Address Family configuration mode
R1(config)#segment-routing	Configuring segment-routing
R1(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
R1(config-srv6)#locators	Configure SRv6 locators
R1(config-srv6-loc)#locator R1_locator	Locator name as R1_locator
R1(config-srv6-loc-conf)# prefix cafe:1:2:all::/64	Ipv6 prefix for locator
R1(config-srv6-loc-conf)#exit-locator	Exit from locator mode
R1(config-srv6-loc)#exit-locators	Exit from srv6 locators configuration mode
R1(config-srv6)#exit-srv6	Exit from srv6 configuration mode
R1(config-router)#commit	Commit the transaction

R2

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Enter interface mode.
R2(config-if)# ip address 12.12.12.12/32 secondary	Configure ip address on the loopback interface as secondary
R2(config)#interface eth1	Enter interface mode.
R2(config-if)# ipv6 address 2424::2/64	Configure the IPv6 address of the interface.
R2(config-if)#ipv6 router isis 1	Make the interface part of the router isis 1 instance.
R2(config-if)#exit	Exit interface mode.
R2(config)#router isis 1	Set the routing process ID as 1
R2(config-router)#is-type level-2	Configure is-type as level-2
R2(config-router)#metric-style wide level-2	Configure wide metric-style
R2(config-router)# net 49.0001.0000.0000.0002.00	Configure Network entity title (NET).
R2(config-router)#mpls traffic-eng level-2	Configure mpls traffic engineering for level-2
R2(config-router)# address-family ipv6	Enter Address-family ipv6
R2(config-router-af)#exit-address-family	Exit address family ipv6
R2(config-router)#commit	Commit the transaction
R2(config-router)#exit	Exit router mode.

R3

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Enter interface mode.
R3(config-if)# ip address 13.13.13.13/32 secondary	Configure ip address on the loopback interface as secondary
R3(config)#interface eth2	Enter interface mode.
R3(config-if)# ipv6 address 65::1/64	Configure the IPv6 address of the interface.
R3(config-router)#exit	Exit router mode.
R3(config)# router bgp 1000	Configure router BGP in AS 1000
R3(config-router)# neighbor 65::2 remote-as 1000	Configure neighbor in remote-as 1000
R3(config-router)# address-family link-state link-state	Enter link-state Address family mode
R3(config-router-af)# neighbor 65::2 activate	Activate IBGP-LS neighbor
R3(config-router-af)#exit-address-family	Exit from Address Family configuration mode

Controller

The following are the step-by-step configurations on the controller router.

Controller#configure terminal	Enter configure mode.
Controller(config)#interface lo	Enter interface mode.
Controller(config-if)# ip address 127.0.0.1/8	Configure ip address on the loopback interface IPV4 address
Controller(config-if)# ip address 1.1.1.1/32 secondary	Configure ip address on the loopback interface as secondary
Controller(config-if)#ipv6 address ::1/128	Configure the IPv6 address of the interface.
Controller(config-router)#exit	Exit router mode.
Controller(config)# router bgp 1	Configure router BGP in AS 1
Controller(config-router)# neighbor 2002::1 remote-as 1000	Configure neighbor in remote-as 1000
Controller(config-router)# address-family link-state link-state	Enter link-state Address family mode
Controller(config-router-af)# neighbor 2002::1 activate	Activate IBGP-LS neighbor
Controller(config-router-af)#exit-address-family	Exit from Address Family configuration mode
Controller(config-router)#exit	Exit router mode.

Validation

R1

Verify R1 Router

```

R1#show  clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1:  VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
0000.0000.0002 xe24      9819.2ca4.1c15    Up     27        L2    IS-IS
R1#
R1#show  isis database verbose
Tag 1:  VRF : default
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00* 0x0000000B  0xEE51        1150          0/0/0
  Area Address: 49.0001
  Topology:      IPv6 (0x2)
  NLPID:         0x8E
  IPv6 Address:  cafe:1:2::11
  Router ID:      11.11.11.11
  IPV6 Router ID:  cafe:1:2::11
  Router Cap:     11.11.11.11
  SR-Algorithm:
    Algorithm: 0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  Metric: 10          IS (MT-IPv6) 0000.0000.0001.03
  Maximum Link Bandwidth: 10g
  TE-Default Metric: 10
  IPv6 Interface Address: 2424::1
  Link Delay : 0 us  Anomalous : 0
  Link Min/Max Delay : 0/0 us, Anomalous : 0
  Link Delay-variation : 0 us
  Link Loss : 0.000000%, Anomalous : 0
  Link Residual Bandwidth: 0k
  Link Available Bandwidth: 0k
  Link Utilized Bandwidth: 0k
  System-ID: 0000.0000.0002  SRV6 LAN END.X SID: cafe:1:2:a11:6001:: End-behaviour: End.X
with PSP (6)
  Metric: 10          IPv6 (MT-IPv6) cafe:1:2::11/128
  Metric: 10          IPv6 (MT-IPv6) 65::/64
  Metric: 10          IPv6 (MT-IPv6) 2424::/64
  Metric: 1           IPv6 (MT-IPv6) cafe:1:2:a11::/64
  SRV6 Locator:        (MT-IPv6)cafe:1:2:a11::/64
    Algorithm: 0  flags: 0  metric: 0
    END SID: cafe:1:2:a11:2001:: flags:0 End-point behaviour: End with PSP (2)
    END SID: cafe:1:2:a11:1001:: flags:0 End-point behaviour: End with USP (3)
    END SID: cafe:1:2:a11:801:: flags:0 End-point behaviour: End with USD (28)
0000.0000.0001.03-00* 0x00000001  0x8345        1047          0/0/0
  Metric: 0           IS-Extended 0000.0000.0001.00
  Metric: 0           IS-Extended 0000.0000.0002.00
0000.0000.0002.00-00 0x0000000E  0x0371        1050          0/0/0
  Area Address: 49.0001
  NLPID:         0x8E
  IPv6 Address: 2424::2
  Metric: 10          IS-Extended 0000.0000.0001.03
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g

```

```

    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    IPv6 Interface Address: 2424::2
    Metric: 10          IPv6 2424::/64

R1# show isis database detail
Tag 1: VRF : default
IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
0000.0000.0001.00-00* 0x0000000B  0xEE51        1146          0/0/0
  Area Address: 49.0001
  Topology:      IPv6 (0x2)
  NLPID:         0x8E
  IPv6 Address:  cafe:1:2::11
  Router ID:     11.11.11.11
  IPV6 Router ID:  cafe:1:2::11
  Router Cap:    11.11.11.11
  SR-Algorithm:
    Algorithm: 0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  SRV6 flags: 0
  Metric: 10      IS (MT-IPv6) 0000.0000.0001.03
  Metric: 10      IPv6 (MT-IPv6) cafe:1:2::11/128
  Metric: 10      IPv6 (MT-IPv6) 65::/64
  Metric: 10      IPv6 (MT-IPv6) 2424::/64
  Metric: 1        IPv6 (MT-IPv6) cafe:1:2:a11::/64
  SRV6 Locator:   (MT-IPv6)cafe:1:2:a11::/64
    Algorithm: 0  flags: 0  metric: 0
    END SID: cafe:1:2:a11:2001::  flags:0  End-point behaviour: End with PSP (2)
    END SID: cafe:1:2:a11:1001::  flags:0  End-point behaviour: End with USP (3)
    END SID: cafe:1:2:a11:801::  flags:0  End-point behaviour: End with USD (28)
0000.0000.0001.03-00* 0x00000001  0x8345        1043          0/0/0
  Metric: 0        IS-Extended 0000.0000.0001.00
  Metric: 0        IS-Extended 0000.0000.0002.00
0000.0000.0002.00-00 0x0000000E  0x0371        1046          0/0/0
  Area Address: 49.0001
  NLPID:         0x8E
  IPv6 Address: 2424::2
  Metric: 10      IS-Extended 0000.0000.0001.03
  Metric: 10      IPv6 2424::/64

R1#
R1#show bgp link-state link-state summary
BGP router identifier 11.11.11.11, local AS number 1000
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
65::1             4    1000    39       100     11      0      0  00:15:12      0
2002::2           4      1     33       87     11      0      0  00:15:12      0

Total number of neighbors 2

Total number of Established sessions 2
R1# show bgp link-state link-state
BGP router identifier 11.11.11.11, local AS number 1000
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, S SRv6 SID
               I Identifier N local node, R remote node, L link P prefix, S SID
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,

```



```

        c confed-ID/ASN, b bgp-identifier, r router-ID, s SID,
        i if-address, n nbr-address, o OSPF Route-type,
        p IP-prefix, d designated router address, s ISO-ID
[V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] /208
[V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.03]] /208
[V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0002.00]] /208
[E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [R[c1000] [b11.11.11.11]
[s0000.0000.0001.03]] /264
[E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.03]] [R[c1000] [b11.11.11.11]
[s0000.0000.0001.00]] /264
[E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.03]] [R[c1000] [b11.11.11.11]
[s0000.0000.0002.00]] /264
[E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0002.00]] [R[c1000] [b11.11.11.11]
[s0000.0000.0001.03]] /264
[T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [p65::/64]] /280
[T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [p2424::/64]] /280
[T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [pcafe:1:2:a11::/64]] /280
[T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [pcafe:1:2::11/128]] /344
[T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0002.00]] [P[t0x0002] [p2424::/64]] /280
[S] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [S[t0x0002]
[scafe:1:2:a11:801::/128]] /344
[S] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [S[t0x0002]
[scafe:1:2:a11:1001::/128]] /344
[S] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [S[t0x0002]
[scafe:1:2:a11:2001::/128]] /344
NLRIs, Total: 15, Node: 3, Link: 4, Prefix: 5, SRv6-SID: 3
R1# show bgp link-state link-state [V] [L2] [I0x1] [N[c1000] [b11.11.11.11]
[s0000.0000.0001.00]] /208
BGP routing table entry for [V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] /208
Local
  Received from IGP
  Link State:
    ISIS area address:49.0001
    Aux Router ID: 11.11.11.11
  SR Algorithm: 0
  SR Flags: I:0 V:0
  SRv6 Capability is enabled - flags 0
  Node MSD
    SRH maximum segments left - 4
    SRH maximum end pop - 4
    SRH maximum H.encaps - 4
    SRH maximum decapsulation sids - 4
  Multi-Topology ID is (0) - Standard Topology
  Node flag bits: O:0 T:0 B:0 E:0
R1#
R1#show bgp link-state link-state [E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]]
[R[c1000] [b11.11.11.11] [s0000.0000.0001.03]] /264
BGP routing table entry for [E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]]
[R[c1000] [b11.11.11.11] [s0000.0000.0001.03]] /264
Local
  Received from IGP
  Link State:
    Local Router ID: 11.11.11.11, Local Ipv6 Router ID: cafe:1:2::11, Max link bw:
1250000000.00 ,
    TE metric 10 , IGP metric 10 Link Delay-variation : 0 us
    Link Loss : 0.000000%, Anomalous : 0
    Link Residual Bandwidth: 0k
    Link Available Bandwidth: 0k
    Link Utilized Bandwidth: 0k
  SRv6 Lan End.X
    SRv6 Lan End.X Endpoint behavior value: 6 - End.X with PSP
    SRv6 Lan End.X Endpoint Flags: 0
    SRv6 Lan End.X Endpoint Algorithm: 0
    SRv6 Lan End.X Endpoint Weight: 0
    SRv6 Lan End.X Endpoint neighbor_id: 0000.0000.0002
    SRv6 Lan End.X SRv6 SID: cafe:1:2:a11:6001::
R1#

```

```

R1#show bgp link-state link-state [T][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[P[t0x0002][pcafe:1:2:a11::/64]]/280
BGP routing table entry for [T][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[P[t0x0002][pcafe:1:2:a11::/64]]/280
Local
  Received from IGP
  Link State:
  Metric: 0      SRv6 Locator Flags :0      SRv6 Locator Algorithm :0      SRv6 Locator Metric :0
R1#show bgp link-state link-state [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:801::/128]]/344
BGP routing table entry for [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:801::/128]]/344
Local
  Received from IGP
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :28 - End with USD      SRv6 flags :0      SRv6 Algorithm :0

R1#show bgp link-state link-state [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:1001::/128]]/344
BGP routing table entry for [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:1001::/128]]/344
Local
  Received from IGP
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :3 - End with USP      SRv6 flags :0      SRv6 Algorithm :0

R1#
R1#show bgp link-state link-state [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:2001::/128]]/344
BGP routing table entry for [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:2001::/128]]/344
Local
  Received from IGP
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :2 - End with PSP      SRv6 flags :0      SRv6 Algorithm :0

R1#
R1#show segment-routing srv6 sid
SRv6 Segment ID table:

```

SID	Operation	Nexthop	Originator
cafe:1:2:a11:801::	END[usd]	::	nsm
cafe:1:2:a11:1001::	END[usp]	::	nsm
cafe:1:2:a11:2001::	END[psp]	::	nsm
cafe:1:2:a11:6001::	END.X[psp]	fe80::9a19:2cff:fea4:1c15isis	

```

R1#

```

R2

Verify R2 Router

```

R2#show clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 1
Total number of adjacencies: 1
Tag 1: VRF : default
System Id      Interface  SNPA              State  Holdtime  Type Protocol
0000.0000.0001 xel17      e8c5.7a09.bc87    Up     6          L2    IS-IS

R2#show isis database verbose
Tag 1: VRF : default
IS-IS Level-2 Link State Database:

```

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
0000.0000.0001.00-00	0x0000000B	0xEE51	1027	0/0/0

```

Area Address: 49.0001
NLPID:      0x8E
IPv6 Address: cafe:1:2::11
Router ID:   11.11.11.11
IPv6 Router ID:  cafe:1:2::11
Router Cap:  11.11.11.11
  SR-Algorithm:
    Algorithm: 0
  Maximum SID Depth:
    SRH maximum segments left : 4
    SRH maximum end pop : 4
    SRH maximum H.encaps : 4
    SRH maximum decapsulation sids : 4
  Unknown Sub-TLV type 25 length 2
0000.0000.0001.03-00 0x00000001 0x8345          924          0/0/0
  Metric: 0          IS-Extended 0000.0000.0001.00
  Metric: 0          IS-Extended 0000.0000.0002.00
0000.0000.0002.00-00* 0x0000000E 0x0371          929          0/0/0
Area Address: 49.0001
NLPID:      0x8E
IPv6 Address: 2424::2
Metric: 10          IS-Extended 0000.0000.0001.03
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
IPv6 Interface Address: 2424::2
Metric: 10          IPv6 2424::/64

R2#

```

R3

Verify R3 Router

```

R3#show bgp link-state link-state summary
BGP router identifier 123.1.1.2, local AS number 1000
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
65::2             4   1000   103      45       6       0       0  00:17:25         15

Total number of neighbors 1

Total number of Established sessions 1
R3#
R3#show bgp link-state link-state
BGP router identifier 123.1.1.2, local AS number 1000
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, S SRv6 SID
               I Identifier N local node, R remote node, L link P prefix, S SID
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID, s SID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID

```

```

i [V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]]/208
i [V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.03]]/208
i [V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0002.00]]/208
i [E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [R[c1000] [b11.11.11.11]
[s0000.0000.0001.03]]/264
i [E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.03]] [R[c1000] [b11.11.11.11]
[s0000.0000.0001.00]]/264
i [E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.03]] [R[c1000] [b11.11.11.11]
[s0000.0000.0002.00]]/264
i [E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0002.00]] [R[c1000] [b11.11.11.11]
[s0000.0000.0001.03]]/264
i [T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [p65::/64]]/280
i [T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [p2424::/64]]/280
i [T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [pcafe:1:2:a11::/64]]/280
i [T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [P[t0x0002] [pcafe:1:2::11/128]]/344
i [T] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0002.00]] [P[t0x0002] [p2424::/64]]/280
i [S] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [S[t0x0002]
[scafe:1:2:a11:801::/128]]/344
i [S] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [S[t0x0002]
[scafe:1:2:a11:1001::/128]]/344
i [S] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]] [S[t0x0002]
[scafe:1:2:a11:2001::/128]]/344
NLRI's, Total: 15, Node: 3, Link: 4, Prefix: 5, SRv6-SID: 3

R3#show bgp link-state link-state [V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]]/208
BGP routing table entry for [V] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]]/208
Local
  Received from 11.11.11.11
  Link State:
    ISIS area address:49.0001
    Aux Router ID: 11.11.11.11
  SR Algorithm: 0
  SR Flags: I:0 V:0
  SRv6 Capability is enabled - flags 0
  Node MSD
    SRH maximum segments left - 4
    SRH maximum end pop - 4
    SRH maximum H.encaps - 4
    SRH maximum decapsulation sids - 4
  Multi-Topology ID is (0) - Standard Topology
  Node flag bits: O:0 T:0 B:0 E:0
R3#

R3#show bgp link-state link-state [E] [L2] [I0x1] [N[c1000] [b11.11.11.11] [s0000.0000.0001.00]]
[R[c1000] [b11.11.11.11]
[s0000.0000.0001.03]]/264
BGP routing table entry for [E] [L2] [I0x1] [N[c1000] [b11.11.11.11]
[s0000.0000.0001.00]] [R[c1000] [b11.11.11.11]
[s0000.0000.0001.03]]/264
Local
  Received from 11.11.11.11
  Link State:
    Local Router ID: 11.11.11.11,    Local Ipv6 Router ID: cafe:1:2::11,
    Max link bw: 1250000000.00 ,
    TE metric 10 ,    IGP metric 10    Link Delay-variation : 0 us
    Link Loss : 0.000000%, Anomalous : 0
    Link Residual Bandwidth: 0k
    Link Available Bandwidth: 0k
    Link Utilized Bandwidth: 0k
  SRv6 Lan End.X
    SRv6 Lan End.X Endpoint behavior value: 6 - End.X with PSP
    SRv6 Lan End.X Endpoint Flags: 0
    SRv6 Lan End.X Endpoint Algorithm: 0
    SRv6 Lan End.X Endpoint Weight: 0
    SRv6 Lan End.X Endpoint neighbor_id: 0000.0000.0002
    SRv6 Lan End.X SRv6 SID: cafe:1:2:a11:6001::
R3#

```

```

R3#show bgp link-state link-state [T][L2][I0x1][N[c1000][b11.11.11.11]
[s0000.0000.0001.00]][P[t0x0002][p65::/64]]/280
BGP routing table entry for [T][L2][I0x1][N[c1000][b11.11.11.11]
[s0000.0000.0001.00]][P[t0x0002][p65::/64]]/280
Local
  Received from 11.11.11.11
  Link State:
  Metric: 10
R3#
R3#show bgp link-state link-state [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]][S
[t0x0002]
[scafe:1:2:a11:801::/128]]/344
BGP routing table entry for [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:801::/128]]/344
Local
  Received from 11.11.11.11
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :28 - End with USD      SRv6 flags :0      SRv6 Algorithm :0
R3#
R3#show bgp link-state link-state sho
R3#show bgp link-state link-state sho bg
R3#show bgp link-state link-state [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]][S
[t0x0002]
[scafe:1:2:a11:1001::/128]]/344
BGP routing table entry for [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:1001::/128]]/344
Local
  Received from 11.11.11.11
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :3 - End with USP      SRv6 flags :0      SRv6 Algorithm :0
R3#show bgp link-state link-state [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]][S
[t0x0002]
[scafe:1:2:a11:2001::/128]]/344
BGP routing table entry for [S][L2][I0x1][N[c1000][b11.11.11.11][s0000.0000.0001.00]]
[S[t0x0002][scafe:1:2:a11:2001::/128]]/344
Local
  Received from 11.11.11.11
  Link State:
  SRv6 Endpoint behavior:
  SRv6 Locator Endpoint :2 - End with PSP      SRv6 flags :0      SRv6 Algorithm :0
R3#

```

BGP On-Demand Next Hop and Auto Steering

This section contains configurations of BGP on-demand next hop (ODN) and auto steering with segment routing. SR Policy is identified by three main components which are: Headend, Endpoint and Color.

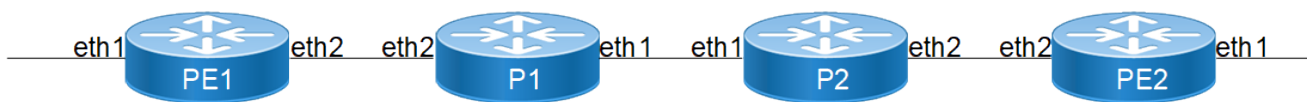
When redistributing routing information across domains, provisioning of multi-domain services (Layer 2 VPN and Layer 3 VPN) has its own complexity and scalability issues.

Segment Routing On-Demand Next Hop (ODN) or SR TE auto steering triggers delegation of computation of an end-to-end LSP using dynamic computation (isis/ospf/pcep) including constraints and policies without doing any redistribution. It then installs the reapplied multi-domain LSP for the duration of the service into the local forwarding information base (FIB).

Coloring plays very important role in automated steering solution. Color information is exchanged by BGP extended community attribute (sub tlv) and BGP tunnel encapsulation attribute in the VPN route UPDATE messages. Egress PE node colors the service routes (VPN routes), advertises to ingress PE with colors that signifies SRTE SLA requirement. Ingress node uses this color to match SR policy, once node identifies SR policy by matching color, it automatically steers traffic onto the SR policy. This is called Automated Steering.

Topology

Figure 39. BGP On-Demand Next Hop (ODN) and Auto Steering



Configurations

Configuring and bring up BGP On-demand next hop and auto steering with Segment-routing on PE1 (Ingress) and PE2 (Egress) nodes.



Note: Segment routing ODN template must be configured before receiving FTN update in NSM.

Ingress PE1 Configuration

Create VRF

The following are the step-by-step configurations on the ingress PE1 router to create VRF.

P1#configure terminal	Enter configure mode
P1(config)#ip vrf vrf1	Create a VRF instance named vrf1
P1(config-if)# rd 100:100	Configure Route Distinguisher for the VRF
P1(config-if)# route-target both 101:101	Configure Route Target import and export

PE1(config-if)# commit	Commit VRF configuration
PE1(config-if)#exit	Exit VRF configuration mode

Access Interface Configuration

The following are the step-by-step configurations on the ingress PE1 router to Access Interface Configuration.

PE1(config)# interface eth1	Enter the interface mode for eth1
PE1(config-if)# ip vrf forwarding vrf1	Bind the VRF instance to the interface
PE1(config-if)# ip address 101.1.1.1/24	Configure IPv4 address
PE1(config-if)# label-switching	Commit interface configurations
PE1(config-if)# exit	Exit interface mode

Configuring Segment-Routing ODN Template

The following are the step-by-step configurations on the ingress PE1 router for Configuring Segment-Routing ODN Template.

PE1#configure terminal	Enter configure mode
PE1(config)#segment-routing	Enter the Segment Routing mode
PE1(config-sr)#traffic-engineering	Enter traffic-engineering mode
PE1(config-sr-te)#on-demand-nexthop 1001	Configure SRODN template
PE1(config-sr-odn)#candidate-path 1	Enter candidate path mode
PE1(config-sr-odn-cp)#dynamic-path ospf 100	Configure dynamic path OSPF
PE1(config-sr-odn-cp)#exit-odn-cp	Exit candidate-path mode
PE1(config-sr-odn)#exit-sr-odn	Exit ODN template mode
PE1(config-sr-te)#exit-te	Exit from traffic-engineering mode
PE1(config-sr)#commit	Commit SR configuration
PE1(config-sr)#exit	Exit from Segment-routing mode

Configuring BGP and Redistribute Connected VRF

The following are the step-by-step configurations on the ingress PE1 router for Configuring BGP and Redistribute Connected VRF.

PE1(config)#router bgp 100	Enter Router BGP mode
----------------------------	-----------------------

PE1(config-router)#bgp router-id 1.1.1.1	Configure BGP router-id
PE1(config-router)#neighbor 4.4.4.4 remote-as 100	Configuring PE2 as iBGP neighbor using it's loopback ip
PE1(config-router)# neighbor 4.4.4.4 update-source lo	Source of routing updates as loopback
PE1(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mod
PE1(config-router-af)# neighbor 4.4.4.4 activate	Enabling VPNv4 Address family for neighbor
PE1(config-router-af)# exit-address-family	Exit Address-family mode
PE1(config-router)#address-family ipv4 vrf vrf1	Configure VRF address family
PE1(config-router-af)# redistribute connected	Redistribute connected router
PE1(config-router-af)# exit-address-family	Exit VRF address family
PE1(config-router)# commit	Commit BGP configurations
PE1(config-router)# exit	Exit form Router BGP mode and return to config mode

Egress PE2 Configuration

Configure VRF

The following are the step-by-step configurations on the egress PE2 router to Configure VRF.

P2#configure terminal	Enter configure mode
PE2(config)#ip vrf vrf1	Create new vrf name vrf1
PE2(config-vrf)#rd 100:100	Assign the route distinguisher (RD) value as 100:100
PE2(config-vrf)#route-target both 101:101	Import routes between route target (RT) ext-communities 101 and 101
PE2(config-vrf)#commit	Commit vrf configuration
PE2(config)#exit	Exit form vrf mode

Access Interface Configuration

The following are the step-by-step configurations on the egress PE2 router to Access Interface Configuration

PE2(config)# interface eth1	Enter the interface mode for eth1
PE2(config-if)# ip vrf forwarding vrf1	Bind the VRF instance to the interface
PE2(config-if)# ip address 101.1.1.1/24	Configure IPv4 address
PE2(config-if)# label-switching	Commit interface configurations
PE2(config-if)# exit	Exit interface mode

Configuring Set Extcommunity Color Under Route-Map

The following are the step-by-step configurations on the egress PE2 router for Configuring Set Extcommunity Color Under Route-Map.

PE2#configure terminal	Enter configure mode
PE2(config)#route-map pfp1 permit 10	Create route-map
PE2(config-route-map)# set extcommunity color 1001	Configure set extcommunity color to route-map
PE2(config-route-map)# commit	Commit the route-map configurations
PE2(config-route-map)# exit	Exit from route-map and return to configuration mode

Configuring BGP and Redistribute Connected VRF

The following are the step-by-step configurations on the egress PE2 router for Configuring BGP and Redistribute Connected VRF

PE2(config)#router bgp 100	Enter Router BGP mode
PE2(config-router)#bgp router-id 4.4.4.4	Configure BGP router-id
PE2(config-router)#neighbor 1.1.1.1 remote-as 100	Configuring PE2 as iBGP neighbor using it's loopback ip
PE2(config-router)# neighbor 1.1.1.1 update-source lo	Source of routing updates as loopback
PE2(config-router)#address-family vpnv4 unicast	Enter VPNv4 Address family mod
PE2(config-router-af)# neighbor 1.1.1.1 activate	Enabling VPNv4 Address family for neighbor
PE2(config-router-af)# exit-address-family	Exit Address-family mode
PE2(config-router)#address-family ipv4 vrf vrf1	Configure VRF address family
PE2(config-router-af)# redistribute	Redistribute connected router

connected route-map pfp1	
PE2(config-router-af)# exit-address-family	Exit VRF address family
PE2(config-router)# commit	Commit BGP configurations
PE2 (config-router) # exit	Exit form Router BGP mode and return to config mode

Validation 1

Validation for the Segment-Routing Policy

```

PE1#show segment-routing policy
Policy-Name
point          State          Forwarding-Info          Color          End-
policy_odn_1_1001_
1.1.1.1          1001          1.1.1.1          UP          18001/po36
PE1#show segment-routing policy detail
Policy-Name: policy_odn_1_1001_1.1.1.1          Color 1001          End-point 1.1.1.1          Tunnel-ID: 1
Admin-Status: UP          Oper-Status: UP for 00:01:53
State Transition Count: 1
CSPF Retry Limit: 100          CSPF Retry Interval: 10
ODN-Policy: True
Binding SID :
BSID: 0
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 100          Path Type: Dynamic(ospf)          CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 1
Segment0[LABEL]: Label :18001
Out-if: po36          Out-label-stack: 18001
Attributes:
Configured:
Affinity:
Metric-type: TE
IP Constraints:
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
Code      FEC          FTN-ID      Nhlfe-ID      Pri      LSP-Type      Out-Label      Out-
Intf      Nexthop
B>      101.1.1.0/24          1          111          Yes      LSP_DEFAULT  29504          -
1.1.1.1
PE1#show mpls vrf-table
Output for IPv4 VRF table with id: 2
Primary FTN entry with FEC: 101.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: N/A
Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
Transport Tunnel id: 1, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, BGP Color:
1001, Color: 1001
Cross connect ix: 42, in intf: - in label: 0 out-segment ix: 111
Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 111, owner: BGP, Stale: NO, BGP out intf: po36, transport out intf:
po36, out label: 29504
Nexthop addr: 1.1.1.1          cross connect ix: 42, op code: Push and Lookup
PE1#show ip bgp vpnv4 all summary
BGP router identifier 65.1.1.1, local AS number 100
BGP table version is 2

```

```

1 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  321     318     2     0     0  00:02:20      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, 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: 101:101 (Default for VRF vrf1)
*>i 101.1.1.0/24    1.1.1.1                0        100      0      ?
*> 1 201.1.1.0      0.0.0.0                0        100    32768  ?
  Announced routes count = 1
  Accepted routes count = 1
Route Distinguisher: 101:101
*>i 101.1.1.0/24    1.1.1.1                0        100      0      ?
  Announced routes count = 0
  Accepted routes count = 1
PE1#

```

Validation 2

Validation for the MPLS vrf-forwarding Table

```

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
Code   FEC              FTN-ID   Nhlfe-ID   Pri   LSP-Type   Out-Label   Out-
Intf    Nexthop
  B>    201.1.1.0/24      1        217        Yes  LSP_DEFAULT 29440       -
        6.6.6.6
PE2#show mpls vrf-table
Output for IPv4 VRF table with id: 2
  Primary FTN entry with FEC: 201.1.1.0/24, id: 1, row status: Active, Tunnel-Policy: N/A
  Owner: BGP, distance: 0, Action-type: Redirect to Tunnel, Exp-bits: 0x0, Incoming DSCP: none
  Transport Tunnel id: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, BGP Color:
  0, Color: 0
    Cross connect ix: 51, in intf: - in label: 0 out-segment ix: 217
    Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 217, owner: BGP, Stale: NO, BGP out intf: pol2, transport out intf:
    pol2, out label: 29440
    Nexthop addr: 6.6.6.6      cross connect ix: 51, op code: Push and Lookup
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: 101:101 (Default for VRF vrf1)
*> 1 101.1.1.0/24    0.0.0.0                0        100    32768  ?
*>i 201.1.1.0        6.6.6.6                0        100      0      ?
  Announced routes count = 1
  Accepted routes count = 1
Route Distinguisher: 101:101
*>i 201.1.1.0        6.6.6.6                0        100      0      ?
  Announced routes count = 0
  Accepted routes count = 1
PE2#show ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 100

```

```
BGP table version is 4
1 BGP AS-PATH entries
0 BGP community entries
Neighbor          V    AS   MsgRcv   MsgSen  TblVer   InQ   OutQ   Up/Down   State/PfxRcd
6.6.6.6           4    100   313     312      4        0      0   00:05:04         1
Total number of neighbors 1
Total number of Established sessions 1
PE2#
```

Operations, Administration and Maintenance (OAM) over SRv6

This section contains configurations of OAM with SRv6.

IPv6 OAM operations can be performed for any SRv6 SID whose behavior allows Upper-Layer header processing for an applicable OAM payload (e.g., ICMPv6, UDP).

Ping

Ping to an SRv6 SID is used to verify that the SID is reachable and is locally programmed at the target node.

Traceroute

Traceroute to a SRv6 SID is used for hop-by-hop fault localization as well as path tracing to a SID.

IPv6 OAM operations can be performed with the target SID in the IPv6 destination address without an SRH or with an SRH where the target SID is the last segment. In general, OAM operations to a target SID may not exercise all of its processing depending on its behavior definition.

This document only illustrates ICMPv6-based ping and UDP-based traceroute to an SRv6 SID.

For example, ping to an End.X SID only validates the SID is locally programmed at the target node and does not validate switching to the correct outgoing interface.

Topology

Figure 40. OAM over SRv6 Topology



Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE2(config)#bfd interval 3 minrx 3 multiplier 3	Configure bfd interval 3 min 3 multiplier 3
PE1(config)#bfd multihop-peer cafe:1:2::11 interval 250 minrx 250 multiplier 50	Configure bfd multihop peer interval 250 min 250 multiplier 50
PE1 (config)#commit	Commit the candidate configuration to the running configuration
PE1 (config)#tunnel-policy policy0	Configure tunnel policy

PE1(config-tnl-policy)# color 1	Configure color code
PE1(config-tnl-policy)# tunnel-type srv6	Configure tunnel type as srv6
PE1(config-tnl-policy)#exit	Exit from tunnel policy
PE1(config)#ip vrf vrf103	Configure ip vrf vrf name
PE1(config-vrf)# tunnel-select-policy policy0	tunnel-policy to be mapped
PE1(config-vrf)# rd 10:103	Configure route distinguisher value
PE1(config-vrf)# route-target both 10:103	Configure route-target import and export
PE1(config-vrf)#exit	Exit from vrf mode
PE1(config)#segment-routing	Enable Segment Routing
PE1(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
PE1(config-srv6)#locators	Configure SRv6 locators
PE1(config-srv6-loc)#locator SR7029	Configure SRv6 locator name
PE1(config-srv6-loc-conf)#prefix cafe:1:2:all::/64	Configure prefix for locator
PE1(config-srv6-loc-conf)#exit-locator	Exit from locator
PE1(config-srv6-loc)#exit-locators	Exit from locators
PE1(config-srv6)# exit-srv6	Exit from srv6 mode
PE1(config-sr)#traffic-engineering	Configure Segment Routing traffic engineering
PE1(config-sr-te)#segment-list PE1-PE2	Segment List configuration
PE1(config-sr-sl)#index 1 segment-type-2 cafe:1:2:a22:2001::	Specify the entry index Segment-descriptor type: SRv6 Prefix
PE1(config-sr-sl)#exit-sr-sl	Exit from segment list
PE1(config-sr-te)#policy P1	Configure policy policy name
PE1(config-sr-pol)#color 1 end-point cafe:1:2::22	SR Policy color value policy end point ipv6 address
PE1(config-sr-pol)#candidate-path 1	Configure policy candidate path value
PE1(config-sr-pol-cp)#explicit segment-list PE1-PE2	Configure explicit candidate path segment list with name of the SID list
PE1(config-sr-pol-cp)#exit-pol-cp	Exit from policy
PE1(config-sr-te)#exit-te	Exit from traffic engineer
PE1(config-sr)#exit	Exit from segment routing
PE1(config)#commit	Commit the candidate configuration to the running configuration

PE1(config)#interface lo	Enter the interface mode
PE1(config-if)#ip address 29.29.29.29/32 secondary	Assign the ipv4 address
PE1(config-if)#ipv6 address cafe:1:2::11/128	Assign the ipv6 address
PE1(config-if)# ipv6 router ospf area 0.0.0.0 tag 100 instance-id 0	Configure ospf area as 0 tag is 100 and instance id as 0
PE1(config-if)#exit	Exit from interface mode
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#interface ce1.4001	Enter the sub-interface mode
PE1(config-if)# encapsulation dot1q 4001	Enable encapsulate dot1q vlan id
PE1(config-if)# ip vrf forwarding vrf103	Enable vrf forwarding vrf name
PE1(config-if)# ip address 103.21.1.1/24	Assign the ip address
PE1(config-if)#exit	Exit from interface mode
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#interface ce15	Enter the interface mode
PE1(config-if)# load-interval 30	Enable load interval
PE1(config-if)# ipv6 address 1000::1/64	Assign the ipv6 address
PE1(config-if)# mtu 9216	Set the mtu size
PE1(config-if)# ipv6 nd suppress-ra	Enable ipv6 supress ra
PE1(config-if)# ipv6 ospf network point-to-point instance-id 0	Configure ip ospf network as point to point
PE1(config-if)# ipv6 router ospf area 0.0.0.0 tag 100 instance-id 0	Configure ospf area as 0 tag 100 and instance id as 0
PE1(config-if)#exit	Exit from interface mode
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#router ipv6 ospf 100	Configure ospf instance
PE1(config-router)# router-id 29.29.29.29	Configure ospf router id
PE1(config-router)# bfd all-interfaces	Enable bfd all interfaces
PE1(config-router)# segment-routing srv6	Enable segment routing srv6

PE1(config-router-srv6)# srv6-locator SR7029	Configure srv6 locator name
PE1(config-router-srv6)# exit-srv6	Exit from srv6
PE1(config-router)#exit	Exit from router ospf mode
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#router bgp 65010	Configure bgp instance
PE1(config-router)# bgp router-id 29.29.29.29	Configure bgp router id
PE1(config-router)# neighbor cafe:1:2::22 remote-as 65010	Configure neighbor remote as 65010
PE1(config-router)# neighbor cafe:1:2::22 update-source lo	Configure neighbor update loopback
PE1(config-router)# address-family vpnv4 unicast	Configure address family vpnv4 unicast
PE1(config-router-af)# segment-routing srv6	Enable segment routing srv6
PE1(config-router-vpnv4-srv6)# srv6-locator SR7029	Enable srv6 locator name
PE1(config-router-vpnv4-srv6)# exit-srv6	Exit from srv6
PE1(config-router-af)# neighbor cafe:1:2::22 activate	Activate the ipv6 neighbor
PE1(config-router-af)# neighbor cafe:1:2::22 capability extended-nexthop-encode	Configure neighbor ipv6 address capability extended nexthop encode
PE1(config-router-af)# exit-address-family	Exit from address family
PE1(config-router)# address-family ipv4 vrf vrf103	Enter address family ipv4 vrf vrf name
PE1(config-router-af)# redistribute connected	Configure redistribute connected
PE1(config-router-af)# segment-routing srv6	Configure segment routing srv6
PE1(config-router-vrfv4-srv6)# sid-alloc per-vrf	Configure sid per vrf
PE1(config-router-vrfv4-srv6)# exit-srv6	Exit from srv6
PE1(config-router-af)# exit-address-family	Exit from address family
PE1(config-router)#exit	Exit from bgp instance

PE1 (config) #commit	Commit the candidate configuration to the running configuration
----------------------	---

P

The following are the step-by-step configurations on the P router.

P#configure terminal	Enter configure mode.
P(config)#bfd interval 3 minrx 3 multiplier 3	Configure bfd interval 3 min 3 multiplier 3
P(config)#bfd multihop-peer cafe:1:2::33 interval 250 minrx 250 multiplier 50	Configure bfd multihop peer interval 250 min 250 multiplier 50
P(config)#commit	Commit the candidate configuration to the running configuration
P(config)#segment-routing	Enable Segment Routing
P(config-sr)#srv6	Segment-Routing over IPv6 Data-Plane
P(config-srv6)#locators	Configure SRv6 locators
P(config-srv6-loc)#locator SR7030	Configure SRv6 locator name
P(config-srv6-loc-conf)#prefix cafe:1:2:33::/64	Configure prefix for locator
P(config-srv6-loc-conf)#exit-locator	Exit from locator
P(config-srv6-loc)#exit-locators	Exit from locators
P(config-srv6)#exit-srv6	Exit from srv6 mode
P(config-sr)#exit	Exit from segment routing mode
P(config)#commit	Commit the candidate configuration to the running configuration
P(config)#interface lo	Enter the interface mode
P(config-if)#ip address 30.30.30.30/32 secondary	Assign the ipv4 address
P(config-if)#ipv6 address cafe:1:2::33/128	Assign the ipv6 address
P(config-if)# ipv6 router ospf area 0.0.0.0 tag 100 instance-id 0	Configure ospf area as 0 tag is 100 and instance id as 0
P(config-if)#exit	Exit from interface mode
P(config)#commit	Commit the candidate configuration to the running configuration
P(config)#interface ce4	Enter the interface mode

P(config-if)# load-interval 30	Enable load interval
P(config-if)# ipv6 address 2000::2/64	Assign the ipv6 address
P(config-if)# mtu 9216	Set the mtu size
P(config-if)# ipv6 nd suppress-ra	Enable ipv6 suppress ra
P(config-if)# ipv6 ospf network point-to-point instance-id 0	Configure ip ospf network as point to point
P(config-if)# ipv6 router ospf area 0.0.0.0 tag 100 instance-id 0	Configure ospf area as 0 tag 100 and instance id as 0
P(config-if)#exit	Exit from interface mode
P(config)#commit	Commit the candidate configuration to the running configuration
P(config)#interface ce5	Enter the interface mode
P(config-if)# load-interval 30	Enable load interval
P(config-if)# ipv6 address 1000::2/64	Assign the ipv6 address
P(config-if)# mtu 9216	Set the mtu size
P(config-if)# ipv6 nd suppress-ra	Enable ipv6 suppress ra
P(config-if)# ipv6 ospf network point-to-point instance-id 0	Configure ip ospf network as point to point
P(config-if)# ipv6 router ospf area 0.0.0.0 tag 100 instance-id 0	Configure ospf area as 0 tag 100 and instance id as 0
P(config-if)#exit	Exit from interface mode
P(config)#commit	Commit the candidate configuration to the running configuration
P(config)#router ipv6 ospf 100	Configure ospf instance
P(config-router)# router-id 30.30.30.30	Configure ospf router id
P(config-router)# bfd all-interfaces	Enable bfd all interfaces
P(config-router)# segment-routing srv6	Enable segment routing srv6
P(config-router-srv6)# srv6-locator SR7030	Configure srv6 locator name
P(config-router-srv6)# exit-srv6	Exit from srv6

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
------------------------	-----------------------

PE2 (config) #tunnel-policy policy0	Configure tunnel policy
PE2 (config-tnl-policy) # color 1	Configure color code
PE2 (config-tnl-policy) # tunnel-type srv6	Configure tunnel type as srv6
PE2 (config-tnl-policy) #exit	Exit from tunnel policy
PE2 (config) #ip vrf vrf103	Configure ip vrf vrf name
PE2 (config-vrf) # tunnel-select-policy policy0	tunnel-policy to be mapped
PE2 (config-vrf) # rd 10:103	Configure route distinguisher value
PE2 (config-vrf) # route-target both 10:103	Configure route-target import and export
PE2 (config-vrf) #exit	Exit from vrf mode
PE2 (config) #commit	Commit the candidate configuration to the running configuration
PE2 (config) #bfd interval 3 minrx 3 multiplier 3	Configure bfd interval 3 min 3 multiplier 3
PE2 (config) #bfd multihop-peer cafe:1:2::11 interval 250 minrx 250 multiplier 50	Configure bfd multihop peer interval 250 min 250 multiplier 50
PE2 (config) #commit	Commit the candidate configuration to the running configuration
PE2 (config) #segment-routing	Enable Segment Routing
PE2 (config-sr) #srv6	Segment-Routing over IPv6 Data-Plane
PE2 (config-srv6) #locators	Configure SRv6 locators
PE2 (config-srv6-loc) #locator SR7028	Configure SRv6 locator name
PE2 (config-srv6-loc-conf) #prefix cafe:1:2:a22::/64	Configure prefix for locator
PE2 (config-srv6-loc-conf) #exit-locator	Exit from locator
PE2 (config-srv6-loc) #exit-locators	Exit from locators
PE2 (config-srv6) #exit-srv6	Exit from srv6 mode
PE2 (config-sr) #traffic-engineering	Configure Segment Routing traffic engineering
PE2 (config-sr-te) #segment-list PE1-PE2	Segment List configuration
PE2 (config-sr-sl) #index 1 segment-type-2 cafe:1:2:a11:2001::	Specify the entry index Segment-descriptor type SRv6 Prefix
PE2 (config-sr-sl) #exit-sr-sl	Exit from segment list
PE2 (config-sr-te) # policy P1	Configure policy policy name

PE2(config-sr-pol)#color 1 end-point cafe:1:2::11	SR Policy color value policy end point ipv6 address
PE2(config-sr-pol)#candidate-path 1	Configure policy candidate path value
PE2(config-sr-pol-cp)#explicit segment- list PE1-PE2	Configure explicit candidate path segment list with name of the SID list
PE2(config-sr-pol-cp)#exit-pol-cp	Exit from candidate path
PE2(config-sr-pol)#exit-sr-pol	Exit from policy
PE2(config-sr-te)#exit-te	Exit from traffic engineer
PE2(config-sr)#exit	Exit from segment routing
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#interface lo	Enter the interface mode
PE2(config-if)#ip address 28.28.28.28/32 secondary	Assign the ipv4 address
PE2(config-if)#ipv6 address cafe:1:2::22/128	Assign the ipv6 address
PE2(config-if)#ipv6 router ospf area 0.0.0.0 tag 100 instance-id 0	Configure ospf area as 0 tag is 100 and instance id as 0
PE2(config-if)#exit	Exit from interface mode
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#interface ce4	Enter the interface mode
PE2(config-if)# load-interval 30	Enable load interval
PE2(config-if)# ipv6 address 2000::1/64	Assign the ipv6 address
PE2(config-if)# mtu 9216	Set the mtu size
PE2(config-if)# ipv6 nd suppress-ra	Enable ipv6 supress ra
PE2(config-if)# ipv6 ospf network point-to-point instance-id 0	Configure ip ospf network as point to point
PE2(config-if)# ipv6 router ospf area 0.0.0.0 tag 100 instance-id 0	Configure ospf area as 0 tag 100 and instance id as 0
PE2(config-if)#exit	Exit from interface mode
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#interface ce14.4001	Enter the subinterface mode
PE2(config-if)# encapsulation dot1q 4001	Enable the encapsulate dot 1q vlan id
PE2(config-if)# ip vrf forwarding	Enable vrf forwarding vrf name

vrf103	
PE2(config-if)# ip address 103.22.1.1/24	Assign the ip address
PE2(config-if)#exit	Exit from interface mode
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#router ipv6 ospf 100	Configure ospf instance
PE2(config-router)# router-id 28.28.28.28	Configure ospf router id
PE2(config-router)# bfd all-interfaces	Enable bfd all interfaces
PE2(config-router)# segment-routing srv6	Enable segment routing srv6
PE2(config-router-srv6)# srv6-locator SR7028	Configure srv6 locator name
PE2(config-router-srv6)# exit-srv6	Exit from srv6
PE2(config-router)#exit	Exit from router ospf mode
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#router bgp 65010	Configure bgp instance
PE2(config-router)# bgp router-id 28.28.28.28	Configure bgp router id
PE2(config-router)# neighbor cafe:1:2::11 remote-as 65010	Configure neighbor remote as 65010
PE2(config-router)# neighbor cafe:1:2::11 update-source lo	Configure neighbor update loopback
PE2(config-router)# address-family vpngv4 unicast	Configure address family vpngv4 unicast
PE2(config-router-af)# segment-routing srv6	Enable segment routing srv6
PE2(config-router-vpngv4-srv6)# srv6- locator SR7028	Enable srv6 locator name
PE2(config-router-vpngv4-srv6)# exit- srv6	Exit from srv6
PE2(config-router-af)# neighbor cafe:1:2::11 activate	Activate the ipv6 neighbor
PE2(config-router-af)# neighbor cafe:1:2::11 capability extended- nexthop-encode	Configure neighbor ipv6 address capability extended nexthop encode
PE2(config-router-af)# exit-address- family	Exit from address family

PE2(config-router)# address-family ipv4 vrf vrf103	Enter address family ipv4 vrf vrf name
PE2(config-router-af)# redistribute connected	Configure redistribute connected
PE2(config-router-af)# segment-routing srv6	Configure segment routing srv6
PE2(config-router-vrfv4-srv6)# sid-alloc per-vrf	Configure sid per vrf
PE2(config-router-vrfv4-srv6)# exit-srv6	Exit from srv6
PE2(config-router-af)# exit-address-family	Exit from address family
PE2(config-router)#exit	Exit from bgp instance
PE2(config)#commit	Commit the candidate configuration to the running configuration
PE2(config)#end	End from config mode

Validation

PE1

Verify PE1 Router

```

PE1#show ipv6 ospf neighbor

Total number of full neighbors: 1
OSPFv3 Process (100)
Neighbor ID    Pri   State           Dead Time   Interface    Instance ID
30.30.30.30    1     Full/ -         00:00:30    ce15         0
PE1#
PE1#sh ipv6 ospf database locator

                OSPFv3 Router with ID (29.29.29.29) (Process 100)

                Locator-LSA (Area 0.0.0.0)

LS age: 712
LS Type: Locator LSA
Link State ID: 0.0.39.163
Advertising Router: 28.28.28.28
LS Seq Number: 0x80000001
Checksum: 0xA9F0
Length: 120

Locator-TLV (Length:96):
Route type:0    Algorithm:0
Flags:0        Metric:0
Prefix: cafe:1:2:a22::/64

SRv6 END Sub TLV (Length:20):
Flags:0        Reserved:0
END SID: cafe:1:2:a22:2001::

```

```
End-point behaviour: End with PSP (2)

SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a22:1001::
  End-point behaviour: End with USP (3)

SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a22:801::
  End-point behaviour: End with USD (28)

LS age: 748
LS Type: Locator LSA
Link State ID: 0.0.39.77
Advertising Router: 29.29.29.29
LS Seq Number: 0x80000001
Checksum: 0x73BD
Length: 120

Locator-TLV (Length:96):
  Route type:0      Algorithm:0
  Flags:0      Metric:0
  Prefix: cafe:1:2:a11::/64

SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a11:2001::
  End-point behaviour: End with PSP (2)

SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a11:1001::
  End-point behaviour: End with USP (3)

SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:a11:801::
  End-point behaviour: End with USD (28)

LS age: 344
LS Type: Locator LSA
Link State ID: 0.0.39.163
Advertising Router: 30.30.30.30
LS Seq Number: 0x80000007
Checksum: 0xE788
Length: 120

Locator-TLV (Length:96):
  Route type:0      Algorithm:0
  Flags:0      Metric:0
  Prefix: cafe:1:2:33::/64

SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:33:2001::
  End-point behaviour: End with PSP (2)

SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: cafe:1:2:33:1001::
  End-point behaviour: End with USP (3)

SRv6 END Sub TLV (Length:20):
```

```

Flags:0      Reserved:0
END SID: cafe:1:2:33:801::
End-point behaviour: End with USD (28)

LS age: 344
LS Type: Locator LSA
Link State ID: 0.0.39.167
Advertising Router: 30.30.30.30
LS Seq Number: 0x80000007
Checksum: 0xBFAC
Length: 120

Locator-TLV (Length:96):
Route type:0      Algorithm:0
Flags:0           Metric:0
Prefix: cafe:1:2:33::/64

SRv6 END Sub TLV (Length:20):
Flags:0           Reserved:0
END SID: cafe:1:2:33:2001::
End-point behaviour: End with PSP (2)

SRv6 END Sub TLV (Length:20):
Flags:0           Reserved:0
END SID: cafe:1:2:33:1001::
End-point behaviour: End with USP (3)

SRv6 END Sub TLV (Length:20):
Flags:0           Reserved:0
END SID: cafe:1:2:33:801::
End-point behaviour: End with USD (28)

PE1#sh ipv6 ospf database router

        OSPFv3 Router with ID (29.29.29.29) (Process 100)

                Router-LSA (Area 0.0.0.0)

LS age: 1476
LS Type: Router-LSA
Link State ID: 0.0.0.0
Advertising Router: 28.28.28.28
LS Seq Number: 0x80000006
Checksum: 0x80FA
Length: 40
Flags: 0x00 (-|-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)

Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10147
Neighbor Interface ID: 10147
Neighbor Router ID: 30.30.30.30

LS age: 345
LS Type: Router-LSA
Link State ID: 0.0.0.0
Advertising Router: 29.29.29.29
LS Seq Number: 0x80000007
Checksum: 0xEFD8
Length: 40
Flags: 0x00 (-|-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)

```



```
Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10061
Neighbor Interface ID: 10151
Neighbor Router ID: 30.30.30.30

LS age: 351
LS Type: Router-LSA
Link State ID: 0.0.0.0
Advertising Router: 30.30.30.30
LS Seq Number: 0x8000000A
Checksum: 0xE8C4
Length: 56
Flags: 0x00 (-|-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)

Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10147
Neighbor Interface ID: 10147
Neighbor Router ID: 28.28.28.28

Link connected to: another Router (point-to-point)
Metric: 1
Interface ID: 10151
Neighbor Interface ID: 10061
Neighbor Router ID: 29.29.29.29

PE1#

PE1#sh ip bgp neighbors
BGP neighbor is cafe:1:2::22, remote AS 65010, local AS 65010, internal link
BGP version 4, local router ID 29.29.29.29, remote router ID 28.28.28.28
BGP state = Established, up for 01:13:26
Last read 00:00:17, hold time is 90, keepalive interval is 30 seconds
Neighbor capabilities:
  Route refresh: advertised and received (old and new)
  Address family VPNv4 Unicast: advertised and received
Received 177 messages, 0 notifications, 0 in queue
Sent 177 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 3, neighbor version 3
Index 1, Offset 0, Mask 0x2
AIGP is enabled
  Extended Nexthop Encoding: advertised and received
Community attribute sent to this neighbor (both)
Large Community attribute sent to this neighbor
1 accepted prefixes
1 announced prefixes

Connections established 1; dropped 0
Local host: cafe:1:2::11, Local port: 46015
Foreign host: cafe:1:2::22, Foreign port: 179
Nexthop: 29.29.29.29
Nexthop global: cafe:1:2::11
Nexthop local: ::
BGP connection: non shared network

PE1#

PE1#sh segment-routing srv6 transports
Codes: > - installed P6, * - selected P6, p - stale P6,
```

```

U - unknown P6

Code      FEC      SRv6-Policy-Name  color  Pri  Out-SID      Out-
Intf      Nexthop
>         cafe:1:2::22      P1      1      Y      cafe:1:2:a22:2001::
ce15      fe80::5e07:58ff:fe71:205d

PE1#sh segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:
Service Flags
vrf      FEC      SID      Nexthop      SRv6-
Policy-Name
vpn4     >T      vrf103    103.22.1.0/24    cafe:1:2:a22:8001::    cafe:1:2::22
P1

EVPN:
PE1#
PE1#sh segment-routing srv6 sid
SRv6 Segment ID table:
SID      Operation  Nexthop      Originator
+-----+-----+-----+-----+
cafe:1:2:a11:801::    END[usd]     ::           nsm
cafe:1:2:a11:1001::   END[usp]     ::           nsm
cafe:1:2:a11:2001::   END[psp]     ::           nsm
cafe:1:2:a11:2002::   END.X[psp]    fe80::5e07:58ff:fe71:205dospf
cafe:1:2:a11:8001::   END.DT4      vrf vrf103    bgp:65010
PE1#
PE1#
PE1#sh segment-routing srv6 sid id cafe:1:2:a11:2002::
SID      Operation  Nexthop      Originator
+-----+-----+-----+-----+
cafe:1:2:a11:2002::   END.X        fe80::5e07:58ff:fe71:205dconnected
Last update 00:19:54 ago
PE1#

PE1#sh segment-routing policy

Policy-Name      Color  End-
point      State      Forwarding-Info
P1          cafe:1:2:a22:2001::/ce15
PE1#
PE1#sh segment-routing policy detail

Policy-Name: P1      Color 1      End-point cafe:1:2::22      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:38:54
State Transition Count: 3
CP ID: 1, Active
Preference: 100      Path Type: Explicit      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 1
Segment0[SRv6]: SID :cafe:1:2:a22:2001::
Out-if: ce15      Out-label-stack: cafe:1:2:a22:2001::
Attributes:
Configured:
Explicit segment-list Name: PE1-PE2

PE1#

```

Ping srv6 ipv6 with option

Verify Ping srv6 ipv6 with option

```
PE1#ping srv6 ipv6 cafe:1:2::22
Sending 5 SRV6 Echos to  cafe:1:2::22, timeout is 5 seconds
```

```
Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort
```

```
! seq_num = 1  :: 1.44 ms
! seq_num = 2  :: 0.68 ms
! seq_num = 3  :: 0.34 ms
! seq_num = 4  :: 0.51 ms
! seq_num = 5  :: 0.36 ms
```

```
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.34/0.89/1.44
PE1#
```

```
PE1#ping srv6 ipv6 cafe:1:2::22 interval 10
Sending 5 SRV6 Echos to  cafe:1:2::22, timeout is 5 seconds
```

```
Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort
```

```
! seq_num = 1  :: 0.56 ms
! seq_num = 2  :: 0.67 ms
! seq_num = 3  :: 0.54 ms
! seq_num = 4  :: 0.54 ms
! seq_num = 5  :: 0.50 ms
```

```
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.50/0.59/0.67
PE1#
```

```
PE1#ping srv6 ipv6 cafe:1:2::22 repeat 10
Sending 10 SRV6 Echos to  cafe:1:2::22, timeout is 5 seconds
```

```
Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort
```

```
! seq_num = 1  :: 0.49 ms
! seq_num = 2  :: 0.46 ms
! seq_num = 3  :: 0.48 ms
! seq_num = 4  :: 0.52 ms
! seq_num = 5  :: 0.50 ms
! seq_num = 6  :: 0.56 ms
! seq_num = 7  :: 0.30 ms
! seq_num = 8  :: 0.49 ms
! seq_num = 9  :: 0.45 ms
! seq_num = 10 :: 0.53 ms
```

```
Success Rate is 100.00 percent (10/10)
round-trip min/avg/max = 0.30/0.43/0.56
PE1#
```

```
PE1#ping srv6 ipv6 cafe:1:2::22 source-ip cafe:1:2::11
Sending 5 SRV6 Echos to  cafe:1:2::22, timeout is 5 seconds
```

```
Codes:
```

```
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.73 ms
! seq_num = 2  :: 0.32 ms
! seq_num = 3  :: 0.30 ms
! seq_num = 4  :: 0.42 ms
! seq_num = 5  :: 0.36 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.30/0.51/0.73
PE1#
```

Ping srv6 with Policy

Verify Ping srv6 with Policy

```
PE1#ping srv6 policy P1
Sending 5 SRV6 Echos to P1 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.62 ms
! seq_num = 2  :: 0.29 ms
! seq_num = 3  :: 0.32 ms
! seq_num = 4  :: 0.67 ms
! seq_num = 5  :: 0.53 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.29/0.48/0.67
PE1#

PE1#ping srv6 policy P1 candidate-path 1
Sending 5 SRV6 Echos to P1 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.62 ms
! seq_num = 2  :: 0.52 ms
! seq_num = 3  :: 0.38 ms
! seq_num = 4  :: 0.50 ms
! seq_num = 5  :: 0.44 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.38/0.50/0.62
PE1#

PE1#ping srv6 policy P1 interval 15
Sending 5 SRV6 Echos to P1 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort
```

```
! seq_num = 1  :: 0.65 ms
! seq_num = 2  :: 0.60 ms
! seq_num = 3  :: 0.44 ms
! seq_num = 4  :: 0.58 ms
! seq_num = 5  :: 0.55 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.44/0.55/0.65
PE1#
PE1#ping srv6 policy P1 repeat 15
Sending 15 SRV6 Echos to  P1 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.63 ms
! seq_num = 2  :: 0.40 ms
! seq_num = 3  :: 0.27 ms
! seq_num = 4  :: 0.38 ms
! seq_num = 5  :: 0.34 ms
! seq_num = 6  :: 0.36 ms
! seq_num = 7  :: 0.50 ms
! seq_num = 8  :: 0.63 ms
! seq_num = 9  :: 0.47 ms
! seq_num = 10 :: 0.53 ms
! seq_num = 11 :: 0.48 ms
! seq_num = 12 :: 0.71 ms
! seq_num = 13 :: 0.70 ms
! seq_num = 14 :: 0.54 ms
! seq_num = 15 :: 0.53 ms

Success Rate is 100.00 percent (15/15)
round-trip min/avg/max = 0.27/0.49/0.71
PE1#

PE1#ping srv6 policy P1 source-ip cafe:1:2::11
Sending 5 SRV6 Echos to  P1 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.51 ms
! seq_num = 2  :: 0.48 ms
! seq_num = 3  :: 0.50 ms
! seq_num = 4  :: 0.53 ms
! seq_num = 5  :: 0.35 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.35/0.44/0.53
PE1#
```

Ping srv6 with SID

Verify Ping srv6 with SID

```
PE1#ping srv6 sid cafe:1:2:a22:2002::
Sending 5 SRV6 Echos to  cafe:1:2:a22:2002::, timeout is 5 seconds
```

```

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.42 ms
! seq_num = 2  :: 0.34 ms
! seq_num = 3  :: 0.40 ms
! seq_num = 4  :: 0.32 ms
! seq_num = 5  :: 0.37 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.32/0.37/0.42
PE1#
PE1#ping srv6 sid cafe:1:2:a22:2002:: interval 20
Sending 5 SRV6 Echos to  cafe:1:2:a22:2002::, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.67 ms
! seq_num = 2  :: 0.57 ms
! seq_num = 3  :: 0.49 ms
! seq_num = 4  :: 0.50 ms
! seq_num = 5  :: 0.74 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.49/0.62/0.74
PE1#
PE1#ping srv6 sid cafe:1:2:a22:2002:: repeat 20
Sending 20 SRV6 Echos to  cafe:1:2:a22:2002::, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.71 ms
! seq_num = 2  :: 0.40 ms
! seq_num = 3  :: 0.48 ms
! seq_num = 4  :: 0.52 ms
! seq_num = 5  :: 0.47 ms
! seq_num = 6  :: 0.45 ms
! seq_num = 7  :: 0.39 ms
! seq_num = 8  :: 0.57 ms
! seq_num = 9  :: 0.46 ms
! seq_num = 10 :: 0.56 ms
! seq_num = 11 :: 0.63 ms
! seq_num = 12 :: 0.63 ms
! seq_num = 13 :: 0.52 ms
! seq_num = 14 :: 0.54 ms
! seq_num = 15 :: 0.47 ms
! seq_num = 16 :: 0.53 ms
! seq_num = 17 :: 0.67 ms
! seq_num = 18 :: 0.63 ms
! seq_num = 19 :: 0.47 ms
! seq_num = 20 :: 0.50 ms

Success Rate is 100.00 percent (20/20)
round-trip min/avg/max = 0.39/0.55/0.71
PE1#
PE1#ping srv6 sid cafe:1:2:a22:2002:: source-ip cafe:1:2::11

```

```
Sending 5 SRV6 Echos to  cafe:1:2:a22:2002::, timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.56 ms
! seq_num = 2  :: 0.46 ms
! seq_num = 3  :: 0.32 ms
! seq_num = 4  :: 0.40 ms
! seq_num = 5  :: 0.51 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.32/0.44/0.56
PE1#
```

Ping srv6 with Protocol Origin

Verify Ping srv6 with Protocol Origin

```
PE1#ping srv6 protocol-origin local policy P1
Sending 5 SRV6 Echos to  P1 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.44 ms
! seq_num = 2  :: 0.28 ms
! seq_num = 3  :: 0.33 ms
! seq_num = 4  :: 0.35 ms
! seq_num = 5  :: 0.53 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.28/0.41/0.53
PE1#

PE1#ping srv6 protocol-origin local policy P1 repeat 10
Sending 10 SRV6 Echos to  P1 , timeout is 5 seconds

Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort

! seq_num = 1  :: 0.70 ms
! seq_num = 2  :: 0.24 ms
! seq_num = 3  :: 0.30 ms
! seq_num = 4  :: 0.44 ms
! seq_num = 5  :: 0.42 ms
! seq_num = 6  :: 0.35 ms
! seq_num = 7  :: 0.51 ms
! seq_num = 8  :: 0.62 ms
! seq_num = 9  :: 0.48 ms
! seq_num = 10 :: 0.52 ms

Success Rate is 100.00 percent (10/10)
round-trip min/avg/max = 0.24/0.47/0.70
PE1#
```

Traceroute

Traceroute srv6 with ipv6

```

PE1#traceroute srv6 ipv6 cafe:1:2::22
Traceroute to cafe:1:2::22 ( cafe:1:2::22), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

 1  1000::2 0.73 ms  0.49 ms  0.33 ms
    DA: cafe:1:2::22
    SRH:(cafe:1:2::22,SL = 0)
 2  cafe:1:2::22 0.50 ms  0.51 ms  0.50 ms
    DA: cafe:1:2::22
    SRH:(cafe:1:2::22,SL = 0)
 3  cafe:1:2::22 0.33 ms

PE1#

PE1#traceroute srv6 ipv6 cafe:1:2::22 source-ip cafe:1:2::11
Traceroute to cafe:1:2::22 ( cafe:1:2::22), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

 1  1000::2 0.80 ms  0.46 ms  0.46 ms
    DA: cafe:1:2::22
    SRH:(cafe:1:2::22,SL = 0)
 2  cafe:1:2::22 0.51 ms  0.56 ms  0.36 ms
    DA: cafe:1:2::22
    SRH:(cafe:1:2::22,SL = 0)
 3  cafe:1:2::22 0.51 ms

PE1#

```

Traceroute srv6 with Policy

```

PE1#traceroute srv6 policy P1
Traceroute to P1 ( P1 ), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

 1  1000::2 0.86 ms  0.50 ms  0.39 ms
    DA: cafe:1:2:a22:2001::
    SRH:(cafe:1:2:a22:2001::,SL = 0)
 2  cafe:1:2:a22:2001:: 0.61 ms  0.41 ms  0.57 ms
 3  cafe:1:2:a22:2001:: 0.61 ms

PE1#

PE1#traceroute srv6 policy P1 candidate-path 1
Traceroute to P1 ( P1 ), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

 1  1000::2 0.80 ms  0.49 ms  0.51 ms
    DA: cafe:1:2:a22:2001::
    SRH:(cafe:1:2:a22:2001::,SL = 0)
 2  cafe:1:2:a22:2001:: 0.73 ms  0.57 ms  0.69 ms
 3  cafe:1:2:a22:2001:: 0.49 ms

PE1#

PE1#traceroute srv6 policy P1 source-ip cafe:1:2::11
Traceroute to P1 ( P1 ), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

 1  1000::2 0.72 ms  0.61 ms  0.62 ms

```



```

DA: cafe:1:2:a22:2001::
SRH:(cafe:1:2:a22:2001::,SL = 0)
2  cafe:1:2:a22:2001:: 0.63 ms  0.52 ms  0.49 ms
3  cafe:1:2:a22:2001:: 0.35 ms

PE1#

```

Traceroute srv6 with Protocol Origin

```

PE1#traceroute srv6 protocol-origin local policy P1 candidate-path 1
Traceroute to P1  ( P1 ), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

1  1000::2 0.73 ms  0.50 ms  0.46 ms
   DA: cafe:1:2:a22:2001::
   SRH:(cafe:1:2:a22:2001::,SL = 0)
2  cafe:1:2:a22:2001:: 0.50 ms  0.44 ms  0.50 ms
3  cafe:1:2:a22:2001:: 0.52 ms

PE1#
PE1#traceroute srv6 protocol-origin local policy P1 candidate-path 1 source-ip cafe:1:2::11
Traceroute to P1  ( P1 ), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

1  1000::2 0.71 ms  0.47 ms  0.49 ms
   DA: cafe:1:2:a22:2001::
   SRH:(cafe:1:2:a22:2001::,SL = 0)
2  cafe:1:2:a22:2001:: 0.53 ms  0.29 ms  0.36 ms
3  cafe:1:2:a22:2001:: 0.52 ms

PE1#

```

Traceroute srv6 with SID

```

PE1#traceroute srv6 sid cafe:1:2:a22:2002::
Traceroute to cafe:1:2:a22:2002:: ( cafe:1:2:a22:2002::), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

1  1000::2 0.76 ms  0.66 ms  0.45 ms
   DA: cafe:1:2:a22:2002::
   SRH:(cafe:1:2:a22:2002::,SL = 0)
2  cafe:1:2:a22:2002:: 0.49 ms  0.52 ms  0.60 ms
3  cafe:1:2:a22:2002:: 0.46 ms

PE1#
PE1#traceroute srv6 sid cafe:1:2:a22:2002:: source-ip cafe:1:2::11
Traceroute to cafe:1:2:a22:2002:: ( cafe:1:2:a22:2002::), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort

1  1000::2 0.67 ms  0.47 ms  0.36 ms
   DA: cafe:1:2:a22:2002::
   SRH:(cafe:1:2:a22:2002::,SL = 0)
2  cafe:1:2:a22:2002:: 0.38 ms  0.36 ms  0.66 ms
3  cafe:1:2:a22:2002:: 0.50 ms

PE1#

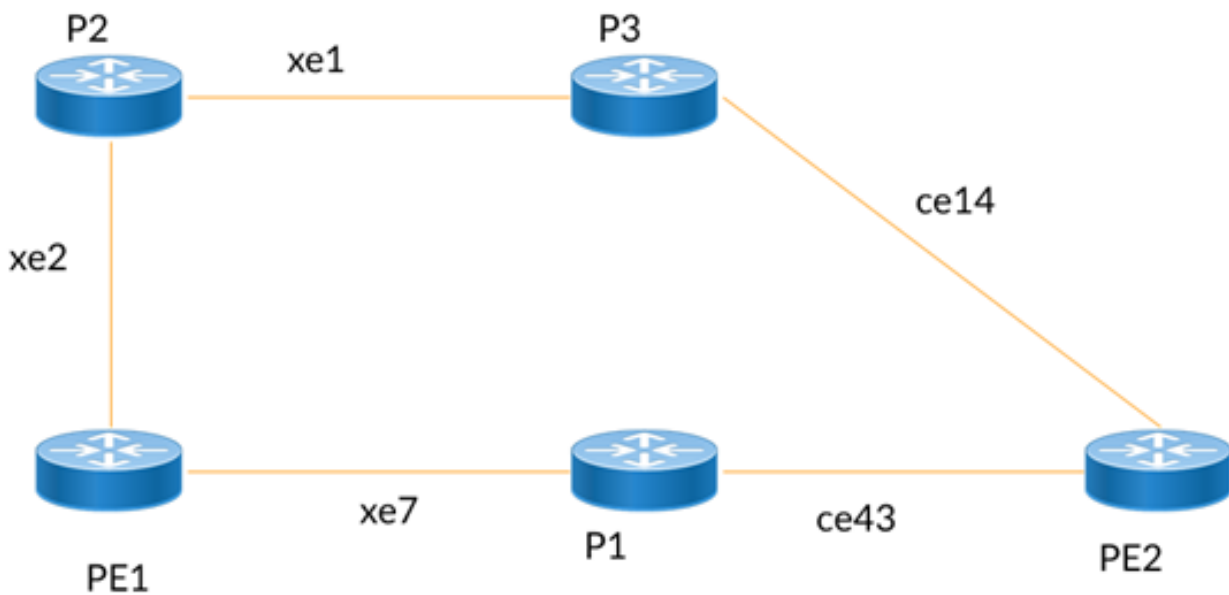
```

ISIS Micro-Loop Avoidance

Micro-loop avoidance provides a mechanism leveraging SR to ensure loop-freeness during the IGP re-convergence process following a link-state change event. Using segment routing, a headend can enforce an explicit path without creating any state along the post-convergence path. As a result, a converging node can enforce traffic on the post-convergence path in a loop-free manner, using a SID list (typically short). So nodes converge over their new optimal path, but temporarily use an SR policy to ensure loop-freeness over that path.

Topology

Figure 41. ISIS-SR micro-loop avoidance



Configuration

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter configure mode.
PE1(config)#hardware-profile micro-bfd enable	Enable hardware profile micro bfd
PE1(config)#bfd interval 3 minrx 3 multiplier 3	Enable bfd interval min with 3 multiplier 3
PE1(config)#qos enable	Enable qos
PE1(config)#vlan database	Configure vlan database
PE1(config-vlan)#vlan 20 bridge 1 state enable	Configure vlan id

PE1(config-vlan)#exit	Exit from vlan mode
PE1(config)#interface lo	Enter loopback interface mode
PE1(config-if)#ip address 26.26.26.26/32 secondary	Configure the secondary IP address of the-loopback interface.
PE1(config-if)#prefix-sid index 100 no-php	Configure sid value with no-php
PE1(config-if)#ip router isis 1	Make the interface part of the router isis instance.
PE1(config-if)#exit	Exit from interface mode.
PE1(config)#interface po1	Configure interface as po1
PE1(config-if)#exit	Exit from interface mode.
PE1(config)#interface po1.10	Configure interface as po1 subinterface
PE1(config-if)#encapsulation dot1q 10	Enable encapsulate dot1q
PE1(config-if)#ip address 10.1.1.26/24	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#isis network point-to-point	Enable network as point to point.
PE1(config-if)#ip router isis 1	Make the interface part of the router isis instance.
PE1(config-if)#exit	Exit from interface mode
PE1(config)#interface vlan1.20	Enter vlan interface mode.
PE1(config-if)#ip address 20.1.1.26/24	Configure the IP address of the interface.
PE1(config-if)#label-switching	Enable label switching.
PE1(config-if)#isis network point-to-point	Enable network as point to point
PE1(config-if)#ip router isis 1	Make the interface part of the router isis instance.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface xe2	Enter interface mode.
PE1(config-if)#switchport	Enter the switchport mode.
PE1(config-if)#bridge-group 1	Enable bridge group
PE1(config-if)#switchport mode trunk	Enter switchport mode trunk
PE1(config-if)#switchport trunk allowed vlan add 20	Enter switchport trunk allow vlan and add vlan id
PE1(config-if)#exit	Exit interface mode.
PE1(config)#interface xe7	Enter interface mode.
PE1(config-if)#channel-group 1 mode active	Enable channel group 1 mode active
PE1(config-if)#exit	Exit interface mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration
PE1(config)#router isis 1	Set the routing process ID.
PE1(config-router)#is-type level-1-2	Enable iks-type as level1-2
PE1(config-router)#spf-interval-exp 10000 10000	Enable spf interval value

PE1(config-router)#metric-style wide	Configure Network entity title (NET).
PE1(config-router)#microloop-avoidance level-1	Enable microloop avoidance as level-1
PE1(config-router)#microloop-avoidance level-2	Enable microloop avoidance as level-2
PE1(config-router)#mpls traffic-eng router-id 26.26.26.26	Enable mpls traffic eng router-id
PE1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE1(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS process.
PE1(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Enable ti-lfa with level-1
PE1(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Enable ti-lfa with level-2
PE1(config-router)#bfd all-interfaces	Enable bfd all interfaces
PE1(config-router)#net 49.0000.0000.0026.00	Configure Network entity title (NET).
PE1(config-router)#passive-interface lo	Enable passive interface with loopback
PE1(config-router)#segment-routing mpls	Enable segment routing mpls ISIS processP1
PE1(config-router)#exit	Exit router mode.
PE1(config)#commit	Commit the candidate configuration to the running configuration

P1

The following are the step-by-step configurations on the P1 router.

P1#configure terminal	Enter configure mode.
P1(config)#hardware-profile micro-bfd enable	Enable hardware profile micro bfd
P1(config)#bfd interval 3 minrx 3 multiplier 3	Enable bfd interval min with 3 multiplier 3
P1(config)#qos enable	Enable qos
P1(config)#interface lo	Enter loopback interface mode
P1(config-if)#ip address 3.3.3.3/32 secondary	Configure the secondary IP address of the-loopback interface.
P1(config-if)#ip router isis 1	Configure sid value with no-php
P1(config-if)#prefix-sid index 200 no-php	Make the interface part of the router isis instance.
P1(config-if)#exit	Exit from interface mode.
P1(config)#interface po1	Configure interface as po1
P1(config-if)#exit	Exit from interface mode.
P1(config)#interface po1.10	Configure interface as po1 subinterface
P1(config-if)#encapsulation dot1q 10	Enable encapsulate dot1q

P1(config-if)#ip address 10.1.1.3/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#isis network point-to-point	Enable network as point to point.
P1(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P1(config-if)#exit	Exit from interface mode
P1(config)#interface po2	Configure interface as po2
P1(config-if)#exit	Exit from interface mode.
P1(config)#interface po2.11	Configure interface as po2 subinterface
P1(config-if)#encapsulation dot1q 11	Enable encapsulate dot1q
P1(config-if)#ip address 11.1.1.3/24	Configure the IP address of the interface.
P1(config-if)#label-switching	Enable label switching.
P1(config-if)#isis network point-to-point	Enable network as point to point.
P1(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P1(config-if)#exit	Exit from interface mode
P1(config)#interface ce43	Enter interface modce
P1(config-if)#channel-group 2 mode active	Enable channel group 2 mode active
P1(config-if)#exit	Exit from interface mode
P1(config)#interface xe7	Enter interface mode
P1(config-if)#channel-group 1 mode active	Enable channel group 1 mode active
P1(config-if)#exit	Exit from interface mode
P1(config)#router isis 1	Set the routing process ID.
P1(config-router)#is-type level-1-2	Enable iks-type as level1-2
P1(config-router)#spf-interval-exp 10000 10000	Enable spf interval value
P1(config-router)#metric-style wide	Configure Network entity title (NET).
P1(config-router)#microloop-avoidance level-1	Enable microloop avoidance as level-1
P1(config-router)#microloop-avoidance level-2	Enable microloop avoidance as level-2
P1(config-router)#mpls traffic-eng router-id 3.3.3.3	Enable mpls traffic eng router-id
P1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P1(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P1(config-router)#capability cspf	Enable capability cspf
P1(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS process.
P1(config-router)#set-overload-bit on-startup 120	Configure set overload bit on startup
P1(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Enable ti-lfa with level-1
P1(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Enable ti-lfa with level-2

P1(config-router)#bfd all-interfaces	Enable bfd all interfaces
P1(config-router)#net 49.0000.0000.0003.00	Configure Network entity title (NET).
P1(config-router)#passive-interface lo	Enable passive interface with loopback
P1(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
P1(config-router)#exit	Exit router mode.
P1(config)#commit	Commit the candidate configuration to the running configuration

P2

The following are the step-by-step configurations on the P router.

P2#configure terminal	Enter configure mode.
P2(config)#hardware-profile micro-bfd enable	Enable hardware profile micro bfd
P2(config)#bfd interval 3 minrx 3 multiplier 3	Enable bfd interval min with 3 multiplier 3
P2(config)#qos enable	Enable qos
P2(config)#vlan database	Configure vlan database
P2(config-vlan)#vlan 20 bridge 1 state enable	Configure vlan id
P2(config-vlan)#exit	Exit from vlan mode
P2(config)#interface lo	Enter loopback interface mode
P2(config-if)#ip address 2.2.2.2/32 secondary	Configure the secondary IP address of the-loopback interface.
P2(config-if)#prefix-sid index 400 no-php	Configure sid value with no-php
P2(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P2(config-if)#exit	Exit from interface mode.
P2(config)#interface xe1	Enter the interface mode.
P2(config-if)#ip address 81.1.1.1/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#isis network point-to-point	Enable isis network as point to point.
P2(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P2(config-if)#exit	Exit from interface mode.
P2(config)#interface vlan1.20	Enter vlan interface mode.
P2(config-if)#ip address 20.1.1.3/24	Configure the IP address of the interface.
P2(config-if)#label-switching	Enable label switching.
P2(config-if)#isis network point-to-point	Enable network as point to point
P2(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P2(config)#interface xe2	Enter interface mode.

P2(config-if)#switchport	Enable switchport
P2(config-if)#bridge-group 1	Enable bridge group 1
P2(config-if)#switchport mode trunk	Enable switchport mode trunk
P2(config-if)#switchport trunk allowed vlan add 20	Enable switchport trunk allow vlan with vlan id.
P2(config-if)#exit	Exit from interface mode.
P2(config)#router isis 1	Set the routing process ID.
P2(config-router)#is-type level-1-2	Enable is-type as level1-2
P2(config-router)#spf-interval-exp 10000 10000	Enable spf interval value
P2(config-router)#metric-style wide	Configure metric style wide
P2(config-router)#microloop-avoidance level-1	Enable microloop avoidance as level-1
P2(config-router)#microloop-avoidance level-2	Enable microloop avoidance as level-2
P2(config-router)#mpls traffic-eng router-id 2.2.2.2	Enable mpls traffic eng router-id
P2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P2(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS process.
P2(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Enable ti-lfa with level-1
P2(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Enable ti-lfa with level-2
P2(config-router)#bfd all-interfaces	Enable bfd all interfaces
P2(config-router)#net 49.0000.0000.0002.00	Configure Network entity title (NET).
P2(config-router)#passive-interface lo	Enable passive interface with loopback
P2(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
P2(config-router)#exit	Exit router mode.
P2(config)#commit	Commit the candidate configuration to the running configuration

P3

The following are the step-by-step configurations on the P3 router.

P3#configure terminal	Enter configure mode.
P3(config)#bfd interval 3 minrx 3 multiplier 3	Enable bfd interval min with 3 multiplier 3
P3(config)#qos enable	Enable qos
P3(config)#interface lo	Enter loopback interface mode
P3(config-if)#ip address 6.6.6.6/32 secondary	Configure the secondary IP address of the-loopback interface.

P3(config-if)#prefix-sid index 6 no-php	Configure sid value with no-php
P3(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P3(config-if)#exit	Exit from interface mode.
P3(config-if)#interface ce14	Enter interface mode.
P3(config-if)#ip address 82.1.1.2/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#isis network point-to-point	Configure isis network as point to point.
P3(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P3(config-if)#exit	Exit from interface mode
P3(config)#interface xe1	Enter interface mode.
P3(config-if)#ip address 81.1.1.2/24	Configure the IP address of the interface.
P3(config-if)#label-switching	Enable label switching.
P3(config-if)#isis network point-to-point	Configure isis network as point to point.
P3(config-if)#ip router isis 1	Make the interface part of the router isis instance.
P3(config-if)#exit	Exit from interface mode.
P3(config)#router isis 1	Set the routing process ID.
P3(config-router)#is-type level-1-2	Enable iks-type as level1-2
P3(config-router)#spf-interval-exp 10000 10000	Enable spf interval value
P3(config-router)#metric-style wide	Configure Network entity title (NET).
P3(config-router)#microloop-avoidance level-1	Enable microloop avoidance as level-1
P3(config-router)#microloop-avoidance level-2	Enable microloop avoidance as level-2
P3(config-router)#mpls traffic-eng router-id 6.6.6.6	Enable mpls traffic eng router-id
P3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
P3(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
P3(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS process.
P3(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Enable ti-lfa with level-1
P3(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Enable ti-lfa with level-2
P3(config-router)#bfd all-interfaces	Enable bfd all interfaces
P3(config-router)#net 49.0000.0000.0006.00	Configure Network entity title (NET).
P3(config-router)#passive-interface lo	Enable passive interface with loopback
P3(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
P3(config-router)#exit	Exit router mode.
P3(config)#commit	Commit the candidate configuration to the running configuration

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter configure mode.
PE2(config)#bfd interval 3 minrx 3	Enable bfd interval min with 3 multiplier 3
PE2(config)#qos enable	Enable qos
PE2(config)#interface lo	Enter loopback interface mode
PE2(config-if)#ip address 23.23.23.23/32 secondary	Configure the secondary IP address of the loopback interface.
PE2(config-if)#prefix-sid index 300 no-php	Configure sid value with no-php
PE2(config-if)#ip router isis 1	Make the interface part of the router isis instance.
PE2(config-if)#exit	Exit from interface mode.
PE2(config)#interface po2	Configure interface as po2
PE2(config-if)#exit	Exit from interface mode.
PE2(config)#interface po2.11	Configure interface as po2 subinterface
PE2(config-if)#encapsulation dot1q 11	Enable encapsulate dot1q
PE2(config-if)#ip address 11.1.1.23/24	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#isis network point-to-point	Enable network as point to point.
PE2(config-if)#ip router isis 1	Make the interface part of the router isis instance.
PE2(config-if)#exit	Exit from interface mode
PE2(config)#interface cel4	Enter interface mode.
PE2(config-if)#ip address 82.1.1.1/24	Configure the IP address of the interface.
PE2(config-if)#label-switching	Enable label switching.
PE2(config-if)#isis network point-to-point	Enable network as point to point.
PE2(config-if)#ip router isis 1	Make the interface part of the router isis instance.
PE2(config-if)#exit	Exit from interface mode.
PE2(config)#interface ce43	Enter interface mode.
PE2(config-if)#channel-group 2 mode active	Enable channel group 2 mode active
PE2(config-if)#exit	Exit from interface mode.
PE2(config)#router isis 1	Set the routing process ID.
PE2(config-router)#is-type level-1-2	Enable iks-type as level1-2
PE2(config-router)#spf-interval-exp 10000 10000	Enable spf interval value
PE2(config-router)#metric-style wide	Enable metric style wide
PE2(config-router)#microloop-avoidance level-1	Enable microloop avoidance as level-1
PE2(config-router)#microloop-avoidance level-2	Enable microloop avoidance as level-2
PE2(config-router)#mpls traffic-eng router-id	Enable mpls traffic eng router-id

23.23.23.23	
PE2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
PE2(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2.
PE2(config-router)#dynamic-hostname	Enable dynamic-hostname under ISIS process.
PE2(config-router)#fast-reroute ti-lfa level-1 proto ipv4	Enable ti-lfa with level-1
PE2(config-router)#fast-reroute ti-lfa level-2 proto ipv4	Enable ti-lfa with level-2
PE2(config-router)#bfd all-interfaces	Enable bfd all interfaces
PE2(config-router)#net 49.0000.0000.0023.00	Configure Network entity title (NET).
PE2(config-router)#passive-interface lo	Enable passive interface with loopback
PE2(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
PE2(config-router)#exit	Exit router mode.
PE2(config)#commit	Commit the candidate configuration to the running configuration



Note: By default, PHP is enabled. To see all the labels in MPLS forwarding and ILM tables, we have enabled with non-php option.

Validation

Validation 1

Verify ISIS neighbor adjacency between routers.

```

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              vlan1.20  e8c5.7a76.581d      Up    19         L1L2 IS-IS
P1              pol.10    3417.ebe4.af32      Up    19         L1L2 IS-IS
PE1#

P1#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
PE1             pol.10     b86a.9725.a7f2      Up    26         L1L2 IS-IS
PE2             po2.11     5c07.5819.4890      Up    24         L1L2 IS-IS
P1#

P2#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
P3             xe1         e8c5.7a25.f40c    Up    21        L1L2 IS-IS
PE1            vlan1.20    b86a.9725.a7bb    Up    25        L1L2 IS-IS
P2#

P3#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             xe1         e8c5.7a76.581f    Up    22        L1L2 IS-IS
PE2            ce14        5c07.5819.4882    Up    22        L1L2 IS-IS
P3#

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
P3             ce14        e8c5.7a25.f41b    Up    25        L1L2 IS-IS
P1             po2.11      3417.ebe4.af33    Up    27        L1L2 IS-IS
PE2#

```

Validation 2

The command output below displays the details of routers configured with segment routing.

```

PE1#show isis segment-routing capability

Tag 1 Segment-Routing:
-----
Advertisement Router Capability :2.2.2.2
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
Total SID'S Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :3.3.3.3
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999
Total SID'S Supported (SRLB)   :0
SRLB Range List Count          :0
-----
Advertisement Router Capability :6.6.6.6
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :8000
SID Range List Count           :1
SID's Range                    :16000 - 23999

```

```

Total SID'S Supported (SRLB)      :0
SRLB Range List Count             :0
-----
Advertisement Router Capability    :23.23.23.23
Algorithm0                        :0
SRMS Preference                   :0
Total SID'S Supported             :8000
SID Range List Count              :1
SID's Range                       :16000 - 23999
Total SID'S Supported (SRLB)      :0
SRLB Range List Count             :0
-----
Advertisement Router Capability    :26.26.26.26
Algorithm0                        :0
SRMS Preference                   :0
Total SID'S Supported             :8000
SID Range List Count              :1
SID's Range                       :16000 - 23999
Total SID'S Supported (SRLB)      :0
SRLB Range List Count             :0
-----
PE1#

```

Validation 3

Verify that segment routing information is present in ISIS database.

```

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
P2.00-00       0x00000013   0x671A        898           0/0/0
  Area Address: 49
  NLPID:        0xCC
  Hostname:     P2
  IP Address:   21.1.1.2
  Router ID:    2.2.2.2
  Router Cap:   2.2.2.2
    SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
  Metric:       10      IS-Extended PE1.00
  IPv4 Interface Address: 20.1.1.2
  Neighbor IP Address: 20.1.1.26
  Maximum Link Bandwidth : 1000000.00 kbits/sec
  Reservable Bandwidth : 1000000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
  TE-Default Metric: 10
  Adjacency SID: 25600  F:0 B:0 V:1 L:1 S:0 P:0
  Metric:       10      IS-Extended P3.00
  IPv4 Interface Address: 81.1.1.1
  Neighbor IP Address: 81.1.1.2
  Maximum Link Bandwidth : 10000000.00 kbits/sec
  Reservable Bandwidth : 10000000.00 kbits/sec
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10000000.00 kbits/sec

```

```

    Unreserved Bandwidth at priority 1: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 10000000.00 kbits/sec
    TE-Default Metric: 10
    Adjacency SID: 25601  F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IP-Extended 21.1.1.0/24
    Metric: 0          IP-Extended 2.2.2.2/32
    Prefix-SID: index 400 R:0 N:1 P:1 E:0 V:0 L:0
    Metric: 10          IP-Extended 20.1.1.0/24
    Metric: 10          IP-Extended 81.1.1.0/24
P1.00-00              0x00000015  0xF8A6 1113 0/0/0
    Area Address: 49
    NLPID: 0xCC
    Hostname: P1
    IP Address: 22.1.1.3
    Router ID: 3.3.3.3
    Router Cap: 3.3.3.3
    SRGB Range: 8000 SRGB Base SID: 16000 I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10          IS-Extended PE1.00
    IPv4 Interface Address: 10.1.1.3
    Neighbor IP Address: 10.1.1.26
    Maximum Link Bandwidth : 1000000.00 kbits/sec
    Reservable Bandwidth : 1000000.00 kbits/sec
    Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
    TE-Default Metric: 10
    Adjacency SID: 25600  F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IS-Extended PE2.00
    IPv4 Interface Address: 11.1.1.3
    Neighbor IP Address: 11.1.1.23
    Maximum Link Bandwidth : 1000000.00 kbits/sec
    Reservable Bandwidth : 1000000.00 kbits/sec
    Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
    TE-Default Metric: 10
    Adjacency SID: 25601  F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IP-Extended 22.1.1.0/24
    Metric: 0          IP-Extended 3.3.3.3/32
    Prefix-SID: index 200 R:0 N:1 P:1 E:0 V:0 L:0
    Metric: 10          IP-Extended 10.1.1.0/24
    Metric: 10          IP-Extended 11.1.1.0/24
P3.00-00              0x00000011  0xF02F 865 0/0/0
    Area Address: 49
    NLPID: 0xCC
    Hostname: P3
    IP Address: 82.1.1.2
    Router ID: 6.6.6.6
    Router Cap: 6.6.6.6

```

```

SRGB Range: 8000    SRGB Base SID: 16000    I:1 V:0
SR-Algorithm:
  Algorithm: 0
Metric: 10          IS-Extended P2.00
IPv4 Interface Address: 81.1.1.2
Neighbor IP Address: 81.1.1.1
Maximum Link Bandwidth : 10000000.00 kbits/sec
Reservable Bandwidth : 10000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 10000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 25600  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE2.00
IPv4 Interface Address: 82.1.1.2
Neighbor IP Address: 82.1.1.1
Maximum Link Bandwidth : 100000000.00 kbits/sec
Reservable Bandwidth : 100000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 25601  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 82.1.1.0/24
Metric: 10          IP-Extended 81.1.1.0/24
Metric: 0           IP-Extended 6.6.6.6/32
  Prefix-SID: index 6 R:0 N:1 P:1 E:0 V:0 L:0
PE2.00-00          0x00000016    0x2CF0    1130    0/0/0
Area Address: 49
NLPID: 0xCC
Hostname: PE2
IP Address: 22.1.1.23
Router ID: 23.23.23.23
Router Cap: 23.23.23.23
SRGB Range: 8000    SRGB Base SID: 16000    I:1 V:0
SR-Algorithm:
  Algorithm: 0
Metric: 10          IS-Extended P1.00
IPv4 Interface Address: 11.1.1.23
Neighbor IP Address: 11.1.1.3
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 27520  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended P3.00
IPv4 Interface Address: 82.1.1.1
Neighbor IP Address: 82.1.1.2

```

```

Maximum Link Bandwidth : 100000000.00 kbits/sec
Reservable Bandwidth : 100000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 27521  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 22.1.1.0/24
Metric: 0           IP-Extended 23.23.23.23/32
Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 11.1.1.0/24
Metric: 10          IP-Extended 82.1.1.0/24
PE1.00-00          * 0x00000016  0x14BF          919          0/0/0
Area Address: 49
NLPID:             0xCC
Hostname:          PE1
IP Address:        10.1.1.26
Router ID:         26.26.26.26
Router Cap:        26.26.26.26
SRGB Range: 8000   SRGB Base SID: 16000  I:1 V:0
SR-Algorithm:
  Algorithm: 0
Metric: 10          IS-Extended P1.00
IPv4 Interface Address: 10.1.1.26
Neighbor IP Address: 10.1.1.3
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 27520  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended P2.00
IPv4 Interface Address: 20.1.1.26
Neighbor IP Address: 20.1.1.2
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 27521  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 0           IP-Extended 26.26.26.26/32
Prefix-SID: index 100 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 20.1.1.0/24
Metric: 10          IP-Extended 10.1.1.0/24

IS-IS Level-2 Link State Database:
LSPID          LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
P2.00-00       0x0000001A  0xB346        898           0/0/0

```

```

Area Address: 49
NLPID:      0xCC
Hostname:    P2
IP Address:  21.1.1.2
Router ID:   2.2.2.2
Router Cap:  2.2.2.2
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric:      10      IS-Extended PE1.00
IPv4 Interface Address: 20.1.1.2
Neighbor IP Address: 20.1.1.26
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 25600   F:0 B:0 V:1 L:1 S:0 P:0
Metric:      10      IS-Extended P3.00
IPv4 Interface Address: 81.1.1.1
Neighbor IP Address: 81.1.1.2
Maximum Link Bandwidth : 10000000.00 kbits/sec
Reservable Bandwidth : 10000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 10000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 25601   F:0 B:0 V:1 L:1 S:0 P:0
Metric:      10      IP-Extended 21.1.1.0/24
Metric:      0      IP-Extended 2.2.2.2/32
  Prefix-SID: index 400 R:0 N:1 P:1 E:0 V:0 L:0
Metric:      10      IP-Extended 20.1.1.0/24
Metric:      20      IP-Extended 3.3.3.3/32
  Prefix-SID: index 200 R:1 N:0 P:1 E:0 V:0 L:0
Metric:      20      IP-Extended 10.1.1.0/24
Metric:      30      IP-Extended 22.1.1.0/24
Metric:      10      IP-Extended 26.26.26.26/32
  Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
Metric:      30      IP-Extended 11.1.1.0/24
Metric:      20      IP-Extended 23.23.23.23/32
  Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric:      10      IP-Extended 81.1.1.0/24
Metric:      20      IP-Extended 82.1.1.0/24
Metric:      10      IP-Extended 6.6.6.6/32
  Prefix-SID: index 6 R:1 N:0 P:1 E:0 V:0 L:0
P1.00-00      0x0000001D   0x49B9      1113      0/0/0
Area Address: 49
NLPID:      0xCC
Hostname:    P1
IP Address:  22.1.1.3
Router ID:   3.3.3.3
Router Cap:  3.3.3.3
  SRGB Range: 8000   SRGB Base SID: 16000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0

```



```

Metric: 10          IS-Extended PE1.00
IPv4 Interface Address: 10.1.1.3
Neighbor IP Address: 10.1.1.26
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 25600  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended PE2.00
IPv4 Interface Address: 11.1.1.3
Neighbor IP Address: 11.1.1.23
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 25601  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 22.1.1.0/24
Metric: 0           IP-Extended 3.3.3.3/32
  Prefix-SID: index 200 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 10.1.1.0/24
Metric: 10          IP-Extended 26.26.26.26/32
  Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20          IP-Extended 20.1.1.0/24
Metric: 20          IP-Extended 2.2.2.2/32
  Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30          IP-Extended 21.1.1.0/24
Metric: 10          IP-Extended 11.1.1.0/24
Metric: 10          IP-Extended 23.23.23.23/32
  Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30          IP-Extended 81.1.1.0/24
Metric: 20          IP-Extended 82.1.1.0/24
Metric: 20          IP-Extended 6.6.6.6/32
  Prefix-SID: index 6 R:1 N:0 P:1 E:0 V:0 L:0
P3.00-00           0x00000012  0xDC43      865      0/0/0
Area Address: 49
NLPID: 0xCC
Hostname: P3
IP Address: 82.1.1.2
Router ID: 6.6.6.6
Router Cap: 6.6.6.6
  SRGB Range: 8000  SRGB Base SID: 16000  I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10          IS-Extended P2.00
IPv4 Interface Address: 81.1.1.2
Neighbor IP Address: 81.1.1.1
Maximum Link Bandwidth : 10000000.00 kbits/sec
Reservable Bandwidth : 10000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 10000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 10000000.00 kbits/sec

```

```

    Unreserved Bandwidth at priority 3: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 4: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 5: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 6: 10000000.00 kbits/sec
    Unreserved Bandwidth at priority 7: 10000000.00 kbits/sec
    TE-Default Metric: 10
    Adjacency SID: 25600  F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IS-Extended PE2.00
    IPv4 Interface Address: 82.1.1.2
    Neighbor IP Address: 82.1.1.1
    Maximum Link Bandwidth : 100000000.00 kbits/sec
    Reservable Bandwidth : 100000000.00 kbits/sec
    Unreserved Bandwidth:
        Unreserved Bandwidth at priority 0: 100000000.00 kbits/sec
        Unreserved Bandwidth at priority 1: 100000000.00 kbits/sec
        Unreserved Bandwidth at priority 2: 100000000.00 kbits/sec
        Unreserved Bandwidth at priority 3: 100000000.00 kbits/sec
        Unreserved Bandwidth at priority 4: 100000000.00 kbits/sec
        Unreserved Bandwidth at priority 5: 100000000.00 kbits/sec
        Unreserved Bandwidth at priority 6: 100000000.00 kbits/sec
        Unreserved Bandwidth at priority 7: 100000000.00 kbits/sec
    TE-Default Metric: 10
    Adjacency SID: 25601  F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IP-Extended 82.1.1.0/24
    Metric: 10          IP-Extended 81.1.1.0/24
    Metric: 0           IP-Extended 6.6.6.6/32
    Prefix-SID: index 6 R:0 N:1 P:1 E:0 V:0 L:0
    Metric: 10          IP-Extended 2.2.2.2/32
    Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
    Metric: 20          IP-Extended 3.3.3.3/32
    Prefix-SID: index 200 R:1 N:0 P:1 E:0 V:0 L:0
    Metric: 30          IP-Extended 10.1.1.0/24
    Metric: 20          IP-Extended 11.1.1.0/24
    Metric: 20          IP-Extended 20.1.1.0/24
    Metric: 20          IP-Extended 21.1.1.0/24
    Metric: 20          IP-Extended 22.1.1.0/24
    Metric: 10          IP-Extended 23.23.23.23/32
    Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
    Metric: 20          IP-Extended 26.26.26.26/32
    Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
    PE2.00-00          0x0000001A  0x6918          1130          0/0/0
    Area Address: 49
    NLPID: 0xCC
    Hostname: PE2
    IP Address: 22.1.1.23
    Router ID: 23.23.23.23
    Router Cap: 23.23.23.23
    SRGB Range: 8000    SRGB Base SID: 16000  I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10          IS-Extended P1.00
    IPv4 Interface Address: 11.1.1.23
    Neighbor IP Address: 11.1.1.3
    Maximum Link Bandwidth : 1000000.00 kbits/sec
    Reservable Bandwidth : 1000000.00 kbits/sec
    Unreserved Bandwidth:
        Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
        Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
        Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
        Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
        Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
        Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
        Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
        Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
    TE-Default Metric: 10
    Adjacency SID: 27520  F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10          IS-Extended P3.00
    IPv4 Interface Address: 82.1.1.1

```

```

Neighbor IP Address: 82.1.1.2
Maximum Link Bandwidth : 100000000.00 kbits/sec
Reservable Bandwidth : 100000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 100000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 100000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 27521  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IP-Extended 22.1.1.0/24
Metric: 0          IP-Extended 23.23.23.23/32
  Prefix-SID: index 300 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 11.1.1.0/24
Metric: 10          IP-Extended 3.3.3.3/32
  Prefix-SID: index 200 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20          IP-Extended 10.1.1.0/24
Metric: 20          IP-Extended 2.2.2.2/32
  Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 30          IP-Extended 20.1.1.0/24
Metric: 30          IP-Extended 21.1.1.0/24
Metric: 20          IP-Extended 26.26.26.26/32
  Prefix-SID: index 100 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 10          IP-Extended 82.1.1.0/24
Metric: 20          IP-Extended 81.1.1.0/24
Metric: 10          IP-Extended 6.6.6.6/32
  Prefix-SID: index 6 R:1 N:0 P:1 E:0 V:0 L:0
PE1.00-00          * 0x0000001E 0x0FE6          919          0/0/0
Area Address: 49
NLPID: 0xCC
Hostname: PE1
IP Address: 10.1.1.26
Router ID: 26.26.26.26
Router Cap: 26.26.26.26
  SRGB Range: 8000  SRGB Base SID: 16000  I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10          IS-Extended P1.00
IPv4 Interface Address: 10.1.1.26
Neighbor IP Address: 10.1.1.3
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 27520  F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10          IS-Extended P2.00
IPv4 Interface Address: 20.1.1.26
Neighbor IP Address: 20.1.1.2
Maximum Link Bandwidth : 1000000.00 kbits/sec
Reservable Bandwidth : 1000000.00 kbits/sec
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 1: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 2: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 3: 1000000.00 kbits/sec
  Unreserved Bandwidth at priority 4: 1000000.00 kbits/sec

```

```

Unreserved Bandwidth at priority 5: 1000000.00 kbits/sec
Unreserved Bandwidth at priority 6: 1000000.00 kbits/sec
Unreserved Bandwidth at priority 7: 1000000.00 kbits/sec
TE-Default Metric: 10
Adjacency SID: 27521 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 0 IP-Extended 26.26.26.26/32
Prefix-SID: index 100 R:0 N:1 P:1 E:0 V:0 L:0
Metric: 10 IP-Extended 20.1.1.0/24
Metric: 10 IP-Extended 10.1.1.0/24
Metric: 10 IP-Extended 3.3.3.3/32
Prefix-SID: index 200 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 22.1.1.0/24
Metric: 10 IP-Extended 2.2.2.2/32
Prefix-SID: index 400 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 21.1.1.0/24
Metric: 20 IP-Extended 11.1.1.0/24
Metric: 20 IP-Extended 23.23.23.23/32
Prefix-SID: index 300 R:1 N:0 P:1 E:0 V:0 L:0
Metric: 20 IP-Extended 81.1.1.0/24
Metric: 30 IP-Extended 82.1.1.0/24
Metric: 20 IP-Extended 6.6.6.6/32
Prefix-SID: index 6 R:1 N:0 P:1 E:0 V:0 L:0
PE1#

```

Validation 4

Verify that segment routing is enabled and that prefix SIDs are announced to other routers.

Verify that prefix SIDs are installed as labels in MPLS forwarding table. Verify the same in FTN and ILM tables.

```

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, SR: Disabled
Code  FEC      Out-Intf  ELC      FTN-ID  Nhlfe-ID  Tunnel-ID  Pri  Out-
Label Out-Intf  ELC      NextHop  Algo-Num  UpTime
i> 2.2.2.2/32  -         -         4        28        -         00:35:30  -
-         -         -         -         19        0         Yes      16400    vl
an1.20  No        20.1.1.3  -         -         -         10.1.1.3  -     -
-         No        16400    pol.10    No        01:04:10  -     -
i> 3.3.3.3/32  -         -         1        31        -         01:04:10  -
-         -         -         -         5         0         Yes      16200    po
1.10   No        10.1.1.3  -         -         -         20.1.1.3  -     -
-         No        16200    vlan1.20 No        00:37:08  -     -
i> 6.6.6.6/32  -         -         2        33        -         00:37:08  -
-         -         -         -         22        0         Y es     16006    vl
an1.20  No        20.1.1.3  -         -         -         10.1.1.3  -     -
-         No        16006    pol.10    No        00:03:23  -     -
i> 23.23.23.23/32  -         -         3        36        -         00:37:08  -
-         -         -         -         9         0         Y es     16300    po

```

```

1.10      No      10.1.1.3      -      -
              No      16300      3 5      -      20.1.1.3      -      -
i
(b)> 23.23.23.23/32      5      9      2201      Yes      16300
pol.10      No      10.1.1.3      0      00:03:23
PE1#
PE1#

```

In the forwarding tables above, the configured prefix SIDs are in the Out-Label column which is expected and is global across the topology. The swap happens in between nodes with this prefix SID and there is no local labelling.

Verify the ILM and FTN tables.

```

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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Disabled
Code  FEC/VRF/L2CKT  ILM-ID  In-Label  Out-Label  In-Intf  Out-
Intf/VRF  Nexthop  pri  Algo-Num  UpTime  UPStr  peers
i> 3.3.3.3/32      3      16200      16200      N/A      pol.10      10
.1.1.3      Yes 0      01:04:49      16200      16200      N/A      vlan1.20      20
.1.1.3      No -      -      16100      N/A      N/A      12
i> 26.26.26.26/32  1      16100      N/A      N/A      N/A      12
7.0.0.1      Yes 0      01:15:47      16006      16006      N/A      vlan1.20      20
i> 6.6.6.6/32      4      16006      16006      N/A      pol.10      10
.1.1.3      Yes 0      00:37:47      16006      16006      N/A      vlan1.20      20
.1.1.3      No -      -      16400      16400      N/A      pol.10      10
i> 2.2.2.2/32      6      16400      16400      N/A      vlan1.20      20
.1.1.3      Yes 0      00:36:09      16400      16400      N/A      pol.10      10
.1.1.3      No -      -      16300      16300      N/A      pol.10      10
i> 23.23.23.23/32  5      16300      16300      N/A      pol.10      10
.1.1.3      Yes 0      00:37:47      16300      16300      N/A      vlan1.20      20
.1.1.3      No -      -      24320      3      N/A      pol.10      10
i> 10.1.1.3/32      2      24320      16200      N/A      vlan1.20      20
.1.1.3      Yes 0      01:04:55      24321      3      N/A      vlan1.20      20
.1.1.3      No -      -      24321      16400      N/A      pol.10      10
i> 20.1.1.3/32      7      24321      16400      N/A      pol.10      10
.1.1.3      Yes 0      00:04:10      24321      16400      N/A      pol.10      10
.1.1.3      No -      -
PE1#PE1#show mpls ftn-table
Primary FTN entry with FEC: 2.2.2.2/32, 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, Description: N/A, , Color: 0
Cross connect ix: 5, in intf: - in label: 0 out-segment ix: 7
Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
Out-segment with ix: 7, owner: ISIS-SR, Stale: NO, out intf: vlan1.20, out label: 16400
Nexthop addr: 20.1.1.2      cross connect ix: 5, op code: Push

Non-primary FTN entry with FEC: 2.2.2.2/32, 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: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 14, in intf: - in label: 0 out-segment ix: 21
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 21, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: pol.10, transport
out intf: N/A, out label: 16400
  Nexthop addr: 10.1.1.3          cross connect ix: 14, op code: Push and Lookup

bypass_ftn_ix 6

Primary FTN entry with FEC: 3.3.3.3/32, 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, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 3, in intf: - in label: 0 out-segment ix: 3
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 3, owner: ISIS-SR, Stale: NO, out intf: pol.10, out label: 16200
  Nexthop addr: 10.1.1.3          cross connect ix: 3, op code: Push

Non-primary FTN entry with FEC: 3.3.3.3/32, 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: 0, Protected LSP id: 0, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 15, in intf: - in label: 0 out-segment ix: 23
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 23, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: vlan1.20, transport
out intf: N/A, out label: 16200
  Nexthop addr: 20.1.1.2          cross connect ix: 15, op code: Push and Lookup

bypass_ftn_ix 7

Primary FTN entry with FEC: 6.6.6.6/32, 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, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 13, 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: vlan1.20, out label: 16006
  Nexthop addr: 20.1.1.2          cross connect ix: 13, op code: Push

Non-primary FTN entry with FEC: 6.6.6.6/32, 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, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 16, in intf: - in label: 0 out-segment ix: 25
  Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
  Out-segment with ix: 25, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: pol.10, transport
out intf: N/A, out label: 16006
  Nexthop addr: 10.1.1.3          cross connect ix: 16, op code: Push and Lookup

bypass_ftn_ix 6

Primary FTN entry with FEC: 6.6.6.6/32, 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, QoS Resource id: 0, Description: N/A, , Color: 0
  Cross connect ix: 13, 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: vlan1.20, out label: 16006
  Nexthop addr: 20.1.1.2          cross connect ix: 13, op code: Push
```

```

Primary FTN entry with FEC: 23.23.23.23/32, 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, Description: N/A, , Color: 0
    Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 9
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 9, owner: ISIS-SR, Stale: NO, out intf: pol.10, out label: 16300
      Nexthop addr: 10.1.1.3          cross connect ix: 6, op code: Push

Non-primary FTN entry with FEC: 23.23.23.23/32, 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, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 17, in intf: - in label: 0 out-segment ix: 27
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 27, owner: ISIS-SR, Stale: NO, ISIS-SR out intf: vlan1.20, transport
out intf: N/A, out label: 16300
      Nexthop addr: 20.1.1.2          cross connect ix: 17, op code: Push and Lookup

  bypass_ftn_ix 7

Primary FTN entry with FEC: 23.23.23.23/32, 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, QoS Resource id: 0, Description: N/A, , Color: 0
    Cross connect ix: 6, in intf: - in label: 0 out-segment ix: 9
      Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 9, owner: ISIS-SR, Stale: NO, out intf: pol.10, out label: 16300
      Nexthop addr: 10.1.1.3          cross connect ix: 6, op code: Push

Primary FTN entry with FEC: 2001::/64, id: 4, row status: Active, Tunnel-Policy: N/A, State:
Installed
  Owner: BGP, distance: 0, Action-type: Redirect to LSP, Exp-bits: 0x0, Incoming DSCP: none
  VRF id 0, BGP peer 1717:1717:: BGP prefix 2001::
  Transport Tunnel id: 0, Protected LSP id: 0, Description: N/A, , Color: 0
    Cross connect ix: 11, in intf: - in label: 0 out-segment ix: 15
      Owner: BGP, Persistent: No, Admin Status: Up, Oper Status: Up
      Out-segment with ix: 15, owner: BGP, Stale: NO, BGP out intf: pol.10, transport out intf:
pol.10, out label: 25601
      Nexthop addr: 23.23.23.23      cross connect ix: 11, op code: Push and Lookup
PE1#

```

Validation 5

Verify microloop avoidance setting.

```

PE1#show isis microloop-avoidance
Tag 1: VRF : default
Level-1 status:
  FSM State: OFIB_STABLE

Level-2 status:
  FSM State: OFIB_STABLE

PE1#

PE1#show isis microloop-avoidance previous-info
Tag 1: VRF : default
Level-1 status:
  FSM State: OFIB_HOLDING_DOWN

```

```
Event type: Neighbor Down
Near end: 0000.0000.0026.00    Far end:0000.0000.0003.00
Hold-down timer running: Yes    Time Remaning: 00:00:02.811
Delay timer running: No
```

Level-2 status:

```
FSM State: OFIB_HOLDING_DOWN
Event type: Neighbor Down
Near end: 0000.0000.0026.00    Far end:0000.0000.0003.00
Hold-down timer running: Yes    Time Remaning: 00:00:02.811
Delay timer running: No
```

oFIB Route Table:

	Destination	Metric	Next-Hop	Interface	Tag
PE1#					

```
PE1#show isis microloop-avoidance previous-info
```

```
Tag 1: VRF : default
```

Level-1 status:

```
FSM State: OFIB_ONGOING
Event type: Neighbor Down
Near end: 0000.0000.0026.00    Far end:0000.0000.0003.00
Hold-down timer running: No
Delay timer running: Yes    Time Remaning: 00:00:00.000
```

Level-2 status:

```
FSM State: OFIB_STABLE
```

oFIB Route Table:

	Destination	Metric	Next-Hop	Interface	Tag
L1	22.1.1.0/24	40	20.1.1.2	vlan1.20	0
	Src: 0000.0000.0023				
L1	23.23.23.23/32	30	20.1.1.2	vlan1.20	0
	Src: 0000.0000.0023				
L1	82.1.1.0/24	30	20.1.1.2	vlan1.20	0
	Src: 0000.0000.0006				

```
PE1#
```

```
PE1#show isis microloop-avoidance previous-info
```

```
Tag 1: VRF : default
```

Level-1 status:

```
FSM State: OFIB_STABLE
```

Level-2 status:

```
FSM State: OFIB_STABLE
```

```
PE1#
```

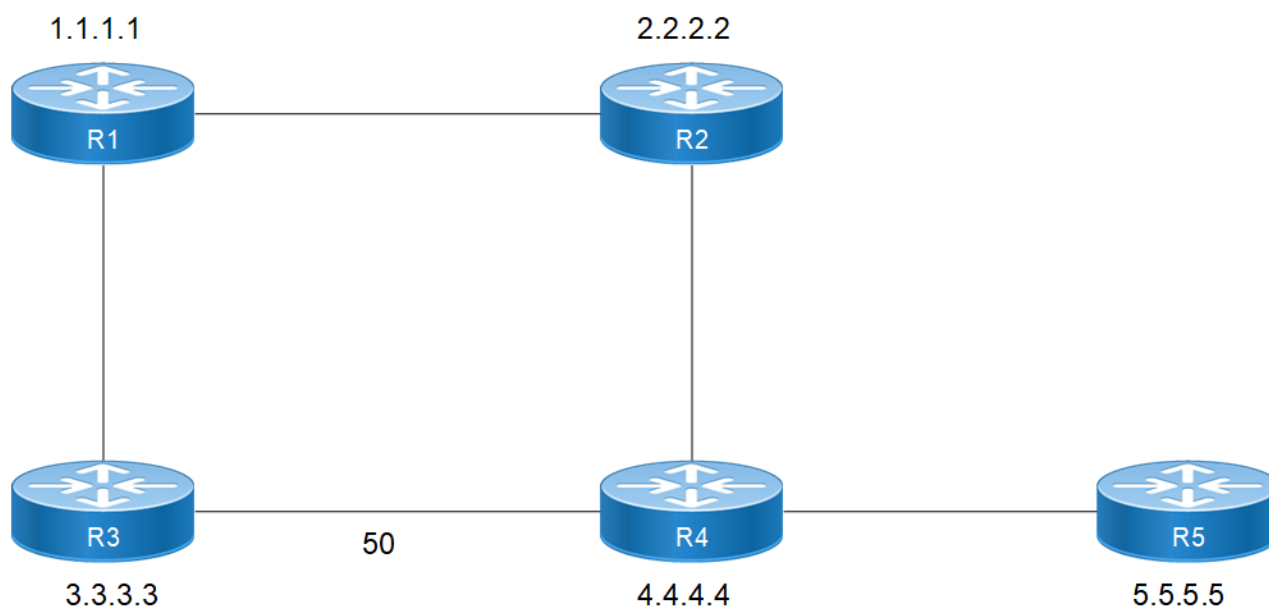

SR based Micro-Loop Avoidance

Overview

SR based Micro-loop avoidance is a mechanism designed to prevent transient forwarding loops that can occur during IGP convergence events such as link flaps, metric changes, or other SPF-triggering events in IP networks, particularly within Segment Routing (SR) enabled domains. The primary goal is to ensure traffic continuity and minimize packet loss during convergence by computing loop-free SR tunnels for nodes at risk of micro-loops.

The Need for Micro-loop Avoidance

Micro-loops are temporary forwarding loops that can occur during IGP convergence, when routers update their forwarding paths at different times after a network change (like a link failures). These loops typically last for a few milliseconds to seconds, but can have serious consequences.



In the given topology, the link between R2 and R4 is initially down. During this state, R3 reaches R5 via R4. When the link between R2 and R4 comes up, the network begins to reconverge, and R3 recalculates its path to R5. Due to the lower cost via R1, R3 updates its next-hop to R1. As a result, R3 updates its forwarding table before R1. Since R1 has not yet converged, it still forwards packets towards R3 based on the old path, creating a transient micro-loop between R3 and R1. Once R1 completes its convergence and updates its path to forward traffic via R2, R2 still operating with the old path may continue forwarding back to R1, leading to a second micro-loop between R1 and R2. Asynchronous convergence in routers can lead to temporary micro-loops in fast-converging IGP networks, underscoring the need for effective micro-loop prevention strategies.

The IS-IS Segment Routing Micro-loop Avoidance feature provides a robust solution to mitigate these issues. It leverages SR-MPLS to ensure loop-freeness during IGP re-convergence following link-state changes, such as link or node failures, or metric updates. Micro-loops occur due to temporary inconsistencies in forwarding tables during these transitions. This feature coordinates synchronized updates to the FIB across routers, effectively reducing

convergence-related packet loss. To ensure optimal protection against micro-loops, this feature should be enabled consistently on all routers within the network.

Feature Characteristics

- Helps prevent micro-loops during ISIS reconvergence.
- Supports both link up/down and metric increase/decrease events.
- Operates with Segment Routing (SR-MPLS) and requires FRR and BFD for immediate failover protection.
- Micro-loop avoidance tunnels are created only on routers that support SR and are configured with a valid Node SID.
- When a router receives a topology update, it checks whether it corresponds to a single link event. If multiple routers report the same event, the router treats them collectively as one link event. However, if the router detects multiple distinct link events, the SR micro-loop avoidance process is aborted.
- Currently, OcNOS supports this feature for IS-IS as the IGP.

Benefits

- **Reduced Packet Loss:** Minimizes traffic loss to under 50ms during convergence by preventing micro-loops.
- **Improved Network Stability:** Ensures consistent forwarding paths during topology changes.
- **Flexible Deployment:** Supports various MPLS-based services and integrates with EVPN and BGP.
- **Enhanced Reliability:** Complements FRR mechanisms like TI-LFA for robust failure handling.
- **Scalability:** Applicable to both Level-1 and Level-2 IS-IS environments with segment routing.

Prerequisites

- IS-IS with Segment Routing (SR) should be configured and operational on all routers.
- MPLS services (such as L2VPN, L3VPN, VPLS, VPWS, 6VPE, 6PE) should be supported and configured as needed.
- Bidirectional Forwarding Detection (BFD) should be enabled for faster failure detection.
- FRR mechanisms namely, TI-LFA, and so on, should be configured to protect against critical link or node failures, with Equal-Cost Multi-Path (ECMP) support also enabled.
- EVPN and BGP should be configured for MPLS services like ELINE.
- All routers should support the micro-loop avoidance feature and have compatible hardware profiles (such as EVPN-MPLS multihoming enabled).

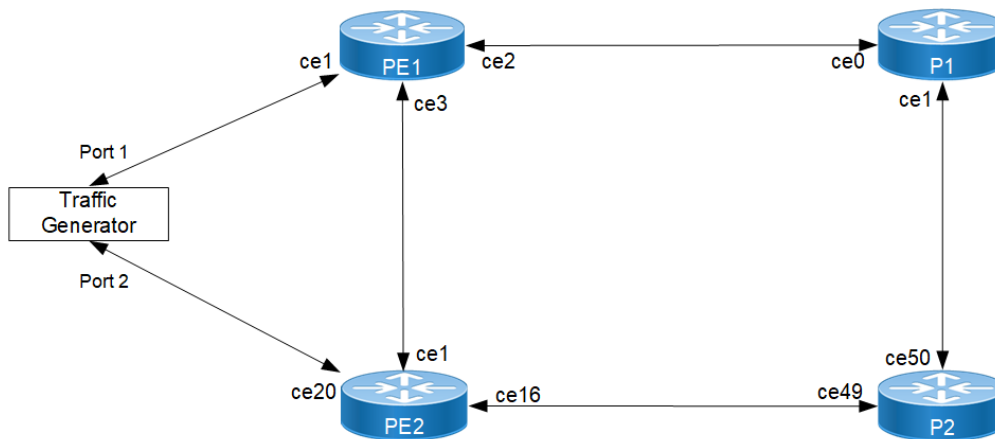
Limitations

- SNMP MIB support for SR micro-loop avoidance is not included in this release.
- Ordered-FIB-based micro-loop avoidance should not be enabled concurrently with SR-based micro-loop avoidance.
- The maximum label depth for loop-free paths is constrained by the label stack depth supported on each device in the network.
- SR micro-loop avoidance for flexible algorithms (Flex-Algo) is not supported.
- No SR micro-loop tunnels are installed for a route/tunnel if SPF results in no changes to its next hops and metrics.

Topology

The topology illustrates an IS-IS Segment Routing network designed for micro-loop avoidance. It includes two Provider Edge routers (PE1 and PE2), two Provider routers (P1 and P2), and two traffic generators (Traffic Generator 1 and Traffic Generator 2). PE1 connects to Traffic Generator 1 via the customer-facing interface ce1, while PE2 connects to Traffic Generator 2 via ce20. The network-side interfaces (ce2, ce3, ce0, ce16, ce49, ce50) link PE1, P1, P2, and PE2, forming a multi-path topology with P1 and P2 interconnected.

Figure 42. ISIS-SR micro-loop avoidance



Configuration

The following steps configure IS-IS Segment Routing Micro-loop Avoidance on routers PE1, P1, P2, and PE2. These steps assume IS-IS SR and MPLS services are already partially configured. For example, only ELINE services are configured. To configure SR Micro-loop functionality on nodes with IS-IS as IGP, follow the steps mentioned below:

1. Configure loop-back interfaces

- Configure loop-back interfaces to serve as stable router identifiers and Segment Routing Prefix SID endpoints in the IS-IS domain.

```
(config)#interface lo
(config-if)#ip address 28.28.28.28/32 secondary
(config-if)#prefix-sid index 28 no-php
(config-if)#ip router isis 1
(config-if)#exit
```



Note: Repeat the above configuration on all PE and P routers with unique loop-back IPs and SID indices.

2. Configure network interface

- Configure the data-plane interfaces to establish IS-IS adjacencies and enable MPLS forwarding for SR traffic.

```
(config)#interface ce2      (config-if)#11.1.1.1/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#load-interval 30
(config-if)#isis network point-to-point
(config-if)#exit

(config)#interface ce3      (config-if)#10.1.1.2/30
(config-if)#mtu 9216
(config-if)#label-switching
(config-if)#ip router isis 1
(config-if)#load-interval 30
(config-if)#isis network point-to-point
(config-if)#exit
```



Note: Apply the respective IP configurations to all IS-IS transport interfaces.

3. Configure IS-IS with Segment Routing and TI-LFA

- Set up IS-IS parameters to enable Segment Routing with MPLS dataplane and configure TI-LFA for fast reroute capabilities.

```
(config)#router isis 1
(config-router)#is-type level-2-only
(config-router)#metric-style wide
(config-router)#mpls traffic-eng router-id 28.28.28.28
(config-router)#mpls traffic-eng level-2
(config-router)#capability cspf
(config-router)#dynamic-hostname
(config-router)#fast-reroute per-prefix level-2 proto ipv4 all
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#bfd all-interfaces
(config-router)#net 49.0000.0000.1028.00
(config-router)#isis segment-routing global block 16000 23999
(config-router)#segment-routing mpls
```



Note: Repeat these steps on all IS-IS nodes in the SR domain with respective parameters.

4. Configure SR based Micro-Loop Avoidance

- Apply FIB update delays to enable ordered convergence and prevent micro-loops during topology changes.

```
(config)#router isis 1
(config-router)# microloop-avoidance segment-routing level-2 proto ipv4 fib-delay 10000
```



Note: Repeat these steps on all the routers.

5. Configure BGP for EVPN

- Establish an EVPN control plane to serve as the MAC/IP route distribution mechanism between provided edge routers (PE1 and PE2).

```
(config)#router bgp 65010
(config-router)#bgp router-id 28.28.28.28
(config-router)#neighbor 44.44.44.44 remote-as 65010
(config-router)#neighbor 44.44.44.44 update-source lo
(config-router)#address-family l2vpn evpn
```

```
(config-router)#neighbor 44.44.44.44 activate
(config-router)#exit-address-family
```

6. Configure MPLS EVPN ELINE Services

- Configure ELINE services using MAC VRFs and EVPN to serve as point-to-point Ethernet services over MPLS between provided edge routers (PE1 and PE2).



Note: Only ELINE services are configured.

```
(config)#evpn mpls enable
(config)#mac vrf 301
(config-vrf)#rd 28.28.28.28:301
(config-vrf)#route-target both 301:301
(config)#evpn mpls vtep-ip-global 28.28.28.28
(config)#evpn mpls id 401 xconnect target-mpls-id 301
(config)#host-reachability-protocol evpn-bgp 301
(config)#interface cel.301 switchport
(config-inf)#encapsulation dot1q 301
(config-inf)#access-if-evpn
(config-access)#map vpn-id 401
```

Configuration Snapshot

PE1

Configuration Snapshot of PE1

```
bfd interval 3 minrx 3 multiplier 3
!
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
evpn mpls enable
!
mac vrf 301
  rd 28.28.28.28:301
  route-target both 301:301
!
evpn mpls vtep-ip-global 28.28.28.28
!
evpn mpls id 401 xconnect target-mpls-id 301
  host-reachability-protocol evpn-bgp 301
!
interface cel.301 switchport
  encapsulation dot1q 301
  access-if-evpn
  map vpn-id 401
!
interface ce2
  load-interval 30
  ip address 11.1.1.1/30
  mtu 9600
  label-switching
  isis network point-to-point
  ip router isis 1
  bfd interval 3 minrx 3 multiplier 3
!
```

```

interface ce3
  speed 100g
  load-interval 30
  ip address 10.1.1.2/30
  mtu 9600
  label-switching
  isis network point-to-point
  ip router isis 1
  bfd interval 3 minrx 3 multiplier 3
!
interface lo
  ip address 127.0.0.1/8
  ip address 28.28.28.28/32 secondary
  ipv6 address ::1/128
  prefix-sid absolute 16028
  ip router isis 1
!
router isis 1
  is-type level-2-only
  metric-style wide
  microloop-avoidance level-2
  mpls traffic-eng router-id 28.28.28.28
  mpls traffic-eng level-2
  capability cspf
  dynamic-hostname
  fast-reroute per-prefix level-2 proto ipv4 all
  fast-reroute ti-lfa level-2 proto ipv4
  bfd all-interfaces
  net 49.0000.0000.1028.00
  isis segment-routing global block 16000 23999
  segment-routing mpls
!
router bgp 65010
  bgp router-id 28.28.28.28
  neighbor 44.44.44.44 remote-as 65010
  neighbor 44.44.44.44 update-source lo
!
  address-family l2vpn evpn
  neighbor 44.44.44.44 activate
  exit-address-family
!
exit
!
!
end

```

P1

Configuration Snapshot P1

```

bfd interval 3 minrx 3 multiplier 3
!
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
evpn mpls enable
!
mac vrf 301
  rd 28.28.28.28:301
  route-target both 301:301
!
evpn mpls vtep-ip-global 28.28.28.28
!
evpn mpls id 401 xconnect target-mpls-id 301

```

```
host-reachability-protocol evpn-bgp 301
!
interface cel.301 switchport
encapsulation dot1q 301
access-if-evpn
map vpn-id 401
!
interface ce2
load-interval 30
ip address 11.1.1.1/30
mtu 9600
label-switching
isis network point-to-point
ip router isis 1
bfd interval 3 minrx 3 multiplier 3
!
interface ce3
speed 100g
load-interval 30
ip address 10.1.1.2/30
mtu 9600
label-switching
isis network point-to-point
ip router isis 1
bfd interval 3 minrx 3 multiplier 3
!
interface lo
ip address 127.0.0.1/8
ip address 28.28.28.28/32 secondary
ipv6 address ::1/128
prefix-sid absolute 16028
ip router isis 1
!
router isis 1
is-type level-2-only
metric-style wide
microloop-avoidance level-2
mpls traffic-eng router-id 28.28.28.28
mpls traffic-eng level-2
capability cspf
dynamic-hostname
fast-reroute per-prefix level-2 proto ipv4 all
fast-reroute ti-lfa level-2 proto ipv4
bfd all-interfaces
net 49.0000.0000.1028.00
isis segment-routing global block 16000 23999
segment-routing mpls
!
router bgp 65010
bgp router-id 28.28.28.28
neighbor 44.44.44.44 remote-as 65010
neighbor 44.44.44.44 update-source lo
!
address-family l2vpn evpn
neighbor 44.44.44.44 activate
exit-address-family
!
exit
!
!
end
```

PE2

Configuration Snapshot of PE2

```
bfd interval 3 minrx 3 multiplier 3
!
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
evpn mpls enable
!
mac vrf 301
  rd 44.44.44.44:301
  route-target both 301:301
!
evpn mpls vtep-ip-global 44.44.44.44
!
evpn mpls id 301 xconnect target-mpls-id 401
  host-reachability-protocol evpn-bgp 301
!
interface cel
  load-interval 30
  ip address 10.1.1.1/30
  mtu 9600
  label-switching
  isis network point-to-point
  ip router isis 1
  bfd interval 3 minrx 3 multiplier 3
!
interface cel6
  fec off
  load-interval 30
  ip address 13.1.1.1/30
  mtu 9600
  label-switching
  isis network point-to-point
  ip router isis 1
  bfd interval 3 minrx 3 multiplier 3
!
interface ce20.301 switchport
  encapsulation dot1q 301
  access-if-evpn
  map vpn-id 301
!
interface lo
  ip address 127.0.0.1/8
  ip address 44.44.44.44/32 secondary
  ipv6 address ::1/128
  prefix-sid absolute 16044
  ip router isis 1
!
exit
!
router isis 1
  is-type level-2-only
  metric-style wide
  microloop-avoidance level-2
  mpls traffic-eng router-id 44.44.44.44
  mpls traffic-eng level-2
  capability cspf
  dynamic-hostname
  fast-reroute per-prefix level-2 proto ipv4 all
  fast-reroute ti-lfa level-2 proto ipv4
  bfd all-interfaces
  net 49.0000.0000.1044.00
  isis segment-routing global block 16000 23999
  segment-routing mpls
!
router bgp 65010
  bgp router-id 44.44.44.44
```



```
neighbor 28.28.28.28 remote-as 65010
neighbor 28.28.28.28 update-source lo
!
address-family l2vpn evpn
neighbor 28.28.28.28 activate
exit-address-family
!
exit
!
!
end
```

P2

Configuration Snapshot of P2

```
bfd interval 3 minrx 3 multiplier 3
!
qos enable
!
mpls ilm-ecmp sr
mpls ftn-ecmp sr
!
evpn mpls enable
!
mac vrf 301
  rd 44.44.44.44:301
  route-target both 301:301
!
evpn mpls vtep-ip-global 44.44.44.44
!
evpn mpls id 301 xconnect target-mpls-id 401
  host-reachability-protocol evpn-bgp 301
!
interface cel
  load-interval 30
  ip address 10.1.1.1/30
  mtu 9600
  label-switching
  isis network point-to-point
  ip router isis 1
  bfd interval 3 minrx 3 multiplier 3
!
interface cel6
  fec off
  load-interval 30
  ip address 13.1.1.1/30
  mtu 9600
  label-switching
  isis network point-to-point
  ip router isis 1
  bfd interval 3 minrx 3 multiplier 3
!
interface ce20.301 switchport
  encapsulation dot1q 301
  access-if-evpn
  map vpn-id 301
!
interface lo
  ip address 127.0.0.1/8
  ip address 44.44.44.44/32 secondary
  ipv6 address ::1/128
  prefix-sid absolute 16044
  ip router isis 1
!
exit
```

```

!
router isis 1
  is-type level-2-only
  metric-style wide
  microloop-avoidance level-2
  mpls traffic-eng router-id 44.44.44.44
  mpls traffic-eng level-2
  capability cspf
  dynamic-hostname
  fast-reroute per-prefix level-2 proto ipv4 all
  fast-reroute ti-lfa level-2 proto ipv4
  bfd all-interfaces
  net 49.0000.0000.1044.00
  isis segment-routing global block 16000 23999
  segment-routing mpls
!
router bgp 65010
  bgp router-id 44.44.44.44
  neighbor 28.28.28.28 remote-as 65010
  neighbor 28.28.28.28 update-source lo
!
  address-family l2vpn evpn
  neighbor 28.28.28.28 activate
  exit-address-family
!
exit
!
!
end

```

Validation

Verify the configuration using the following commands on each router:

```

PE1#sh isis microloop-avoidance segment-routing info
IS-IS level-2 proto-IPv4, microloop-avoidance segment-routing is enabled
  fib-delay 10000 ms.
  algorithm_num: 0
microloop-avoidance segment-routing SPF stage: Inactive
PE1#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, (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: Disabled

```

Code	FEC		FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-	
Intf	ELC	Nexthop		Algo-Num	UpTime				
i>	29.29.29.29/32		5	25	-	-	-	-	-
	-	0		00:00:28					
	11.1.1.2	-	-	21	0	Yes	16029	ce2	No
				24	-				
	No	16029	ce3	No	10.1.1.1	-	-	-	-
i>	30.30.30.30/32		1	13	-	-	-	-	-
	-	0		00:19:05					
	11.1.1.2	-	-	3	0	Yes	16030	ce2	No
				6	-				
	No	3	ce3	No	10.1.1.1	-	-	-	-
				9	0	Yes	16030	ce3	No
	10.1.1.1	-	-						
				1	-				
	No	3	ce2	No	11.1.1.2	-	-	-	-

```

i
(b)> 30.30.30.30/32 3 9 2201 Yes 16030 ce3 No
      10.1.1.1 0 00:14:17
i
(b)> 30.30.30.30/32 4 3 2202 Yes 16030 ce2 No
      11.1.1.2 0 00:14:17
i> 44.44.44.44/32 2 19 - - - - -
    - 0 00:14:18 18 0 Yes 16044 ce3 No
      10.1.1.1 - - 15 - - -
          No 16044 ce2 No 11.1.1.2 - -
PE1#
PE1#sh 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, UPStr - upstream

ILM-ECMP LDP: Disabled, SR: Enabled
Code FEC/VRF/L2CKT ILM-ID In-Label Out-Label In-Intf Out-
Intf/VRF Nexthop pri Algo-Num UpTime UPStr peers
i> 29.29.29.29/32 6 16029 3 N/A ce2 11.
1.1.2 Yes 0 00:07:32 16029 16029 N/A ce3 10.1.
1.1 No - - - 16029 16029 N/A ce3 10.1.
i> 28.28.28.28/32 5 16028 Nolabel N/A N/A 127.0
.0.1 Yes 0 00:07:35
i> 44.44.44.44/32 8 16044 3 N/A ce3 10.1.
1.1 Yes 0 00:07:27 16044 16044 N/A ce2 11.1.
1.2 No - - - 16044 16044 N/A ce2 11.1.
i> 30.30.30.30/32 9 16030 16030 N/A ce2 11.1.
1.2 Yes 0 00:01:23 16030 3 N/A ce3 10.1.
1.1 No - - - 16030 16030 N/A ce3 10.1.
1.1 Yes - - - 16030 3 N/A ce2 11.1.
1.2 No - - - 16030 3 N/A ce2 11.1.
i> 11.1.1.2/32 4 26240 3 N/A ce2 11.1.
1.2 Yes 0 00:07:35 26240 16029 N/A ce3 10.1.
1.1 No - - - 16029 16029 N/A ce3 10.1.
B> evpn:401 3 25601 Nolabel N/A N/A 127.0
.0.1 Yes N/A 00:07:35
i> 10.1.1.1/32 7 26241 3 N/A ce3 10.1.
1.1 Yes 0 00:07:31 26241 16044 N/A ce2 11.1.
1.2 No - - - 26241 16044 N/A ce2 11.1.
PE1#
sh evpn mpls xc tunnel
EVPN-MPLS Network tunnel Entries
Source Destination Status Up/Down Update local-evpn-id remote-
evpn-id Ext-Color
=====
28.28.28.28 44.44.44.44 Installed 00:00:34 00:00:34 401 301
---

Total number of entries are 1
PE1#
PE1-7028#sh clns neighbors

Total number of L1 adjacencies: 0
Total number of L2 adjacencies: 2
Total number of adjacencies: 2
Tag 1: VRF : default

```

```

System Id      Interface      SNPA              State  Holdtime  Type  Protocol
P1             ce2             5c07.5828.b460    Up     20        L2    IS-IS
PE2            ce3             5c17.839a.f0b3    Up     27        L2    IS-IS
PE1#
PE1#sh isis topology

Tag 1: VRF : default
IS-IS paths to level-2 routers
System Id      Metric  Next-Hop  Interface      SNPA
PE1            --
P1             10      P1        ce2             5c07.5828.b460
P2             20      P1        ce2             5c07.5828.b460
              PE2        ce3             5c17.839a.f0b3
PE2            10      PE2        ce3             5c17.839a.f0b3

PE1#
PE1#sh 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 1: VRF : default
Total number of routes: 8

      Destination      Metric  Next-Hop      Interface      Tag
C    10.1.1.0/30        10      --            ce3             0
C    11.1.1.0/30        10      --            ce2             0
L2   12.1.1.0/30        20      11.1.1.2      ce2             0
L2   13.1.1.0/30        20      10.1.1.1      ce3             0
C    28.28.28.28/32     10      --            lo              0
L2   29.29.29.29/32     20      11.1.1.2      ce2             0
L2   30.30.30.30/32     30      11.1.1.2      ce2             0
              10.1.1.1      ce3             0
L2   44.44.44.44/32     20      10.1.1.1      ce3             0
PE1#

```

CLI Commands

This section provides the commands required to configure SR micro-loop avoidance under ISIS mode.

micro-loop avoidance segment-routing

Use this command to configure a SR micro-loop avoidance under IS-IS Segment Routing (SR) mode.

Use the no form of this command to disable micro-loop avoidance for under IS-IS Segment Routing (SR) mode.

When micro-loop avoidance is enabled under Segment Routing, the router ensures loop-free convergence by controlling FIB updates across the network during topology changes.

Command Syntax

```

microloop-avoidance segment-routing (level-1 | level-2) (proto ipv4|ipv6 fib-delay) <100-300000>
no microloop-avoidance segment-routing (level-1 | level-2) (proto ipv4|ipv6)

```

Parameter

level-1

Applies Segment Routing micro-loop avoidance logic only to IS-IS Level-1

level-2

Applies Segment Routing micro-loop avoidance logic only to IS-IS Level-2

prot0

Specifies the protocol family (IPv4 or IPv6) to which micro-loop avoidance will be applied

ipv4

Specifies the IPv4 protocol family to which micro-loop avoidance will be applied

ipv6

Specifies the IPv6 protocol family to which micro-loop avoidance will be applied

<100-300000>

Sets the delay in milli-seconds for updating the Forwarding Information Base (FIB). This delay helps prevent micro-loops by controlling the rate at which FIB changes are applied.

Default

If fib-delay is not configured, default fib-delay of 1500ms(1.5sec) is configured.

Command Mode

ISIS router mode

Applicability

This command is introduced in OcNOS version 6.6.1.

Example

The following example shows the enabling of a SR microloop avoidance

```
#configure terminal
(config)#router isis 1
(config-router)#microloop-avoidance segment-routing level-1 proto ipv4 fib-delay 100
(config-router)#microloop-avoidance segment-routing level-2 proto ipv6 fib-delay 1000

#configure terminal
(config)#router isis 1
(config-router)#no microloop-avoidance segment-routing level-1 proto ipv4
(config-router)#no microloop-avoidance segment-routing level-2 proto ipv6
```

TWAMP over EVPN-L3VPN with SR

TWAMP over EVPN L3VPN with SR feature brings together Two-way Active Measurement Protocol (TWAMP), Ethernet Virtual Private Network (EVPN) Layer 3 Virtual Private Network (L3VPN), and Segment Routing (SR) technologies. This integration revolutionizes the way network performance is monitored and managed.

This feature enables a comprehensive analysis of essential network performance metrics, including latency, packet loss, and various performance metrics.

.It provides information for optimizing network performance. With TWAMP over EVPN L3VPN with SR helps in troubleshooting issues, ensuring efficient resource utilization and reliable service delivery.

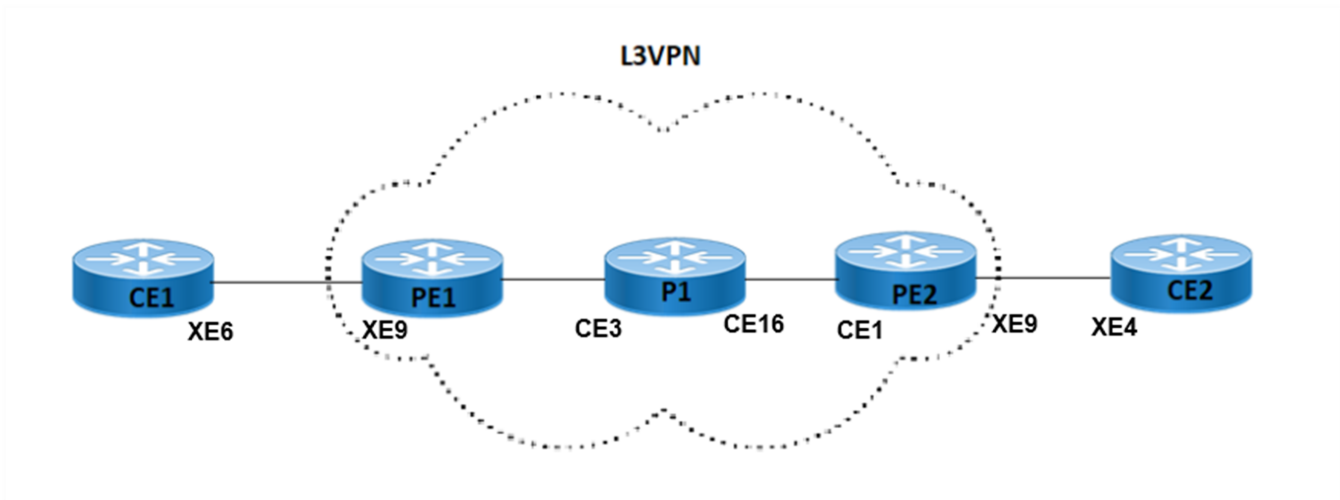
This solution is scalable, making it adaptable to a wide range of network configurations.

Topology

EVPN-L3VPN displays a sample TWAMP over EVPN-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 43. TWAMP over EVPN-L3VPN Topology



SR-MPLS Configuration

PE1

SR-MPLS is configured on PE1 for IGP configs with ISIS and OSPF configuration

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode

(config-if)#ip add 1.1.1.1/32 secondary	Assign IP address to interface
(config-if)#prefix-sid index 100 no-php	Configure sid value with no-php
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#interface xe8	Enter Interface mode
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 10.1.1.1/30	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching.
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-router)#router isis 1	Set the routing process ID
(config-router)#is-type level-2-only	Configure isis level2
(config-router)#metric-style wide	Configure Network entity title (NET).
(config-router)#mpls traffic-eng router-id 1.1.1.1	Enable mpls traffic eng router-id
(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
(config-router)#capability cspf	Enable capability cspf
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#net 49.0001.0000.0001.0011.00	Configures a network with the address 49.0001.0000.0001.0011.00 in a router's configuration
(config-router)#isis segment-routing global block 20000 23000	Enable SRGB range under ISIS process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#router ospf 1	Entering router ospf.
(config-router)#ospf router-id 1.1.1.1	Configure OSPF router-id.
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#network 1.1.1.1/32 area 0.0.0.0	Configures a network with the IP address 1.1.1.1 as a part of OSPF area 0.0.0.0 in a routers configuration.
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Configures a network with the IP address 10.1.1.0 as a part of OSPF area 0.0.0.0 in a routers configuration.
(config-router)#ospf segment-routing global block	Enable SRGB range under OSPF process

16000 19000	
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

P1

SR-MPLS is configured on P1 for IGP configs with ISIS and OSPF configuration.

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip add 2.2.2.2/32 secondary	Assign IP address to interface
(config-if)#prefix-sid index 200 no-php	Configure sid value with no-php
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#interface xe8	Enter interface mode
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 10.1.1.2/30	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching.
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#interface ce0	Enter interface mode
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 20.1.1.1/30	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching.
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#router isis 1	Set the routing process ID
(config-router)#is-type level-2-only	Configure isis level2
(config-router)#metric-style wide	Configure Network entity title (NET).
(config-router)#mpls traffic-eng router-id 2.2.2.2	Enable mpls traffic eng router-id

(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
(config-router)#capability cspf	Enable capability cspf
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#net 49.0001.0000.0001.0022.00	Configure network.
(config-router)#isis segment-routing global block 20000 23000	Enable SRGB range under ISIS process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#router ospf 1	Entering router ospf.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router-id.
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#network 2.2.2.2/32 area 0.0.0.0	Configures a network with the IP address 2.2.2.2 as a part of OSPF area 0.0.0.0 in a router's configuration
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Configures a network with the IP address 10.1.1.0 as a part of OSPF area 0.0.0.0 in a router's configuration.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Configures a network with the IP address 20.1.1.0 as a part of OSPF area 0.0.0.0 in a router's configuration.
(config-router)#ospf segment-routing global block 16000 19000	Enable SRGB range under OSPF process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

PE2

SR-MPLS is configured on PE2 for IGP configs with ISIS and OSPF configuration.

#configure terminal	Enter Configure mode.
(config)#interface lo	Enter interface mode
(config-if)#ip add 3.3.3.3/32 secondary	Assign IP address to interface
(config-if)#prefix-sid index 300 no-php	Configure sid value with no-php
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#interface cel4	Enter interface mode
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 20.1.1.2/30	Assign IP address to interface

(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching.
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#route isis 1	Set the routing process ID
(config-router)#is-type level-2-only	Configure isis level2
(config-router)#metric-style wide	Configure Network entity title (NET).
(config-router)#mpls traffic-eng router-id 3.3.3.3	Enable mpls traffic eng router-id
(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
(config-router)#capability cspf	Enable capability cspf
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#net 49.0001.0000.0001.0033.00	Configure network.
(config-router)#isis segment-routing global block 20000 23000	Enable SRGB range under ISIS process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#router ospf 1	Entering router ospf.
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router-id.
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#network 3.3.3.3/32 area 0.0.0.0	Configure network.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Configure network.
(config-router)#ospf segment-routing global block 16000 19000	Enable SRGB range under OSPF process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

Configure TWAMP over EVPN-L3VPN

PE1

The following are the step-by-step configurations on the PE1 router.

#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)#l3vni 1000	Configure L3 Virtual Network Identifier
(config-vrf)#exit	Exit VRF mode
(config)#interface xe4	Enter Interface mode
(config-if)#mtu 9216	Set the mtu value to interface
(config-if)#exit	Exit Interface mode
(config)#interface xe4.100	Enter Interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(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)#mtu 9216	Set the mtu size
(config-if)#exit	Exit Interface mode
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls irb	Enable EVPN IRB
(config)#evpn mpls vtep-ip-global 1.1.1.1	Configuring VTEP global IP to loopback IP
(config)#router bgp 65010	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 65010	Configure PE2 as an iBGP4+ neighbor
(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 l2vpn evpn	address-family l2vpn evpn]
(config-router-af)#neighbor 3.3.3.3 activate	Activate the PE1 neighbor in the vpnv4 address family
(config-router-af)#exit-address-family	Exit
(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 100	Configure CE2 neighbor in the vrf address family
(config-router-af)#neighbor 100.1.1.2 activate	Activate the CE2 neighbor
(config-router-af)#exit-address-family	Exit form address family
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

PE2

The following are the step-by-step configurations on the PE2 router.

#configure terminal	Enter Configure mode.
(config)#ip vrf vrf100	Create a new VRF named vrf100
(config-vrf)#rd 10:100	Assign the route distinguisher (RD) value as 10:100
(config-vrf)#route-target both 100:1	Import routes between route target (RT) ext-communities 100 and 1
(config-vrf)#l3vni 1000	Configure L3 Virtual Network Identifier
(config-vrf)#exit	Exit VRF mode
(config)#interface ce2	Enter Interface mode
(config-if)#mtu 9216	Set the mtu value to interface
(config-if)#exit	Exit Interface mode
(config)#interface ce2.100	Enter Interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#ip vrf forwarding vrf100	Bind the interface connected to the CE1 router with VRF 100
(config-if)#ip address 200.1.1.1/24	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#exit	Exit Interface mode
(config)#evpn mpls enable	Enable EVPN MPLS
(config)#evpn mpls irb	Enable EVPN IRB
(config)#evpn mpls vtep-ip-global 3.3.3.3	Configuring VTEP global IP to loopback IP
(config)#router bgp 65010	Enter BGP router mode
(config-router)#bgp router-id 3.3.3.3	Configure BGP router-id
(config-router)#neighbor 1.1.1.1 update-source lo	Configure PE2 as an iBGP4+ neighbor
(config-router)#neighbor 1.1.1.1 remote-as 65010	Update the source as loopback for iBGP peering with the remote PE2 router
(config-router)#address-family l2vpn evpn	address-family l2vpn evpn
(config-router-af)#neighbor 1.1.1.1 activate	Activate the PE1 neighbor in the vpnv4 address family
(config-router-af)#exit-address-family	Exit
(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 200.1.1.2 remote-as 200	Configure CE2 neighbor in the vrf address family
(config-router-af)#neighbor 200.1.1.2 activate	Activate the CE2 neighbor
(config-router-af)#exit-address-family	Exit form address family
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

CE1

The following are the step-by-step configurations on the CE1 router.

#configure terminal	Enter Configure mode.
(config)#interface xe4	Enter Interface mode
(config-if)#mtu 9216	Set the mtu size
(config-if)#interface xe4.100	Enter Interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 100.1.1.2/24	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#interface lo	Configure lo interface
(config-if)#ip address 11.11.11.11/32 secondary	Assign IP address to interface
(config-if)#router bgp 100	Enter BGP router mode
(config-router-af)#neighbor 100.1.1.1 remote-as 65010	Configure BGP router-id
(config-router-af)#address-family ipv4 unicast	Enter address-family vpnv4 mode
(config-router-af)#neighbor 100.1.1.1 activate	mode Activate VPNv4 neighbor
(config-router-af)#redistribute connected	Redistribute connected routes
(config-router-af)#commit	Commit the configurations
(config-router-af)#end	Return to privilege mode

CE2

The following are the step-by-step configurations on the CE2 router.

#configure terminal	Enter Configure mode.
(config)#interface ce0	Enter Interface mode
(config)#mtu 9216	Set the mtu size
(config)#interface ce0.100	Enter Interface mode
(config)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config)#load-interval 30	Enable load interval
(config)#ip address 200.1.1.2/24	Assign IP address to interface
(config)#mtu 9216	Set the mtu size
(config-if)#interface lo	Configure lo interface
(config-if)#ip address 22.22.22.22/32 secondary	Assign IP address to interface
(config)#router bgp 200	Enter BGP router mode
(config)#neighbor 200.1.1.1 remote-as 65010	Configure BGP router-id

(config)#address-family ipv4 unicast	Enter address-family vpnv4 mode
(config)#neighbor 200.1.1.1 activate	mode Activate VPNv4 neighbor
(config)#redistribute connected	Redistribute connected routes
(config)#commit	Commit the configurations
(config)#end	Return to privilege mode

TWAMP Configuration on Sender (CE1)

TWAMP sender is configured to measure the delay on interface Loopback on CE1

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP meas- urement configs
(config)#commit	Commit the configuration
(config)# twamp-light control	Enable TWAMP light controller on PE1
(config-twamp-light-ctrl)# control-admin- state enable	Enable TWAMP Controller admin state
(config-twamp-light-ctrl)#delay-profile interfaces	Enter in to delay profile mode
(config-dp-intf)#mode two-way	Enter mode
(config-dp-intf)#burst-count 1	Enter burst count
(config-dp-intf)#burst-interval 1000	Configure burst interval value under delay profile mode
(config-dp-intf)#interval 30	Configure interval
(config-dp-intf)#advertisement periodic threshold 10	Configure advertisement periodic
(config-dp-intf)#advertisement periodic minimum-change 1000	Configure advertisement periodic
(config-dp-intf)#advertisement accelerated	Configure advertisement accelerated
(config-dp-intf)#advertisement accelerated threshold 20	Configure advertisement accelerated threshold
(config-dp-intf)#advertisement accelerated minimum-change 2000	Configure advertisement accelerated
(config-dp-intf)#interface lo	Enter Interface Loopback mode
(config-if)#loss-measurement dynamic	Configure loss measurement
(config-if)#delay-measurement dynamic twamp reflector-ip 22.22.22.22 sender-ip 11.11.11.11	Enter in to delay profile mode
(config-if)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

TWAMP Configuration on Reflector (CE2)

Configure TWAMP Reflector as interface xe24 on CE2 (Towards core)

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP meas- urement 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 CE2-CE1-lo reflector-ip ipv4 22.22.22.22	Configure TWAMP reflector IP as PE2 interface IP
(config-twamp-light-ref)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

Validation

EVPN-L3VPN over SR VALIDATION

- Verify mpls EVPN-L3VPN ping from PE1

```
PE1#sh evpn mpls status
EVPN-MPLS is ACTIVE in Hardware
```

- Verify show evpn mpls tunnel from PE1

```
PE1#show evpn mpls tunnel
EVPN-MPLS Network tunnel Entries
Source      Destination      Status      Up/Down      Update      evpn
-id
=====
===
1.1.1.1      3.3.3.3          Installed    02:50:36     02:50:36    100
Total number of entries are 1
```

- Verify show evpn mpls id 100

```
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     ----          L3      NW      ----      ----
      ----      1.1.1.1      3.3.3.3
Total number of entries are 1
```

- Verify show mpls vrf-forwarding table

```
PE1#sh 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> 22.22.22.22/32    2        0          Yes   LSP_DEFAULT 16
-      3.3.3.3
B> 200.1.1.0/24      1        0          Yes   LSP_DEFAULT 16
-      3.3.3.3
```

- Verify mpls l3vpn ping

```

PE1#ping mpls l3vpn vrf100 200.1.1.0/24 detail
Sending 5 MPLS Echos to 200.1.1.0, 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

! seq_num = 1 20.1.1.2 0.82 ms
! seq_num = 2 20.1.1.2 0.57 ms
! seq_num = 3 20.1.1.2 0.52 ms
! seq_num = 4 20.1.1.2 0.57 ms
! seq_num = 5 20.1.1.2 0.53 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.52/0.67/0.82

PE1#ping mpls l3vpn vrf100 22.22.22.22/32 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 20.1.1.2 0.75 ms
! seq_num = 2 20.1.1.2 0.61 ms
! seq_num = 3 20.1.1.2 0.59 ms
! seq_num = 4 20.1.1.2 0.66 ms
! seq_num = 5 20.1.1.2 0.67 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.59/0.67/0.75

```

TWAMP VALIDATION

- Verify ping between CE1 to CE2

```

CE1#ping 22.22.22.22
Press CTRL+C to exit
PING 22.22.22.22 (22.22.22.22) 56(84) bytes of data.
64 bytes from 22.22.22.22: icmp_seq=1 ttl=62 time=0.564 ms
64 bytes from 22.22.22.22: icmp_seq=2 ttl=62 time=0.426 ms
64 bytes from 22.22.22.22: icmp_seq=3 ttl=62 time=0.848 ms

--- 22.22.22.22 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 61ms
rtt min/avg/max/mdev = 0.426/0.612/0.848/0.177 ms

```

- 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.


```

CE1#show twamp-statistics
=====
TWAMP Test-Session Statistics
=====
Test-Session Name      : __internal_interface_lo
Start Time             : 2023 Oct 16 22:59:07
Elapsed time(milli sec) : 16008
Packets Sent           : 16
Packets Received       : 16
Packet Loss(%)         : 0.00
Round Trip Delay(usec)
  Minimum              : 277
  Maximum              : 595
  Average              : 387
Forward Delay(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Reverse Delay(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Round Trip Delay Variation(usec)
  Minimum              : 220
  Maximum              : 406
  Average              : 300
Forward Delay Variation(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Reverse Delay Variation(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)

(*) - Time is not in sync between Sender and Reflector

```

- Verify twamp-statistics interfaces

```

CE1#sh twamp-statistics interfaces
Interface  Last Advertisement  Delay(us)  Min(us)  Max(us)  Var(us)  Loss(%)
lo 2023-10-16 23:00:52    148      148      148      0        0.00

```

- Verify the Detailed list of TWAMP delay measurement information on CE lo interface

```

CE1#sh twamp-statistics interfaces lo
Interface name      : lo
Sender IP           : 11.11.11.11
Reflector IP        : 22.22.22.22
Reflector port      : 862
DSCP value          : 0
HW Status           : -
Last Advertised stats:
  Time: 2023-10-16 23:01:12
  Average delay      : 145
  Minimum delay      : 106
  Maximum delay      : 165
  Average delay variation: 3
  Minimum delay variation: 2
  Maximum delay variation: 6
  Packets sent       : 13
  Packets received    : 13
  Packets timeout     : 0
  Packet Loss: 0.00
Last Calculated stats:
  Time: 2023-10-16 23:01:12
  Average delay      : 145
  Minimum delay      : 106

```

```
Maximum delay      : 165
Average delay variation: 3
Minimum delay variation: 2
Maximum delay variation: 6
Packets sent       : 13
Packets received   : 13
Packets timeout    : 0
Packet Loss : 0.00
```

TWAMP over L3VPN with SRv6

Two-Way Active Measurement Protocol (TWAMP) is an open protocol designed for assessing network performance between any two devices. TWAMP over SRv6 transport is integrated to enable TWAMP functionality on routers, which assume the roles of MPLS routers, serving as both LERs and intermediate routers. OcNOS also provides end-to-end statistics calculation, supporting multi-path scenarios between the sender and reflector with multihop capabilities.

Users can use the link delay metrics, including average, minimum, maximum delay, and delay variance, to evaluate network latency. Leveraging these metrics is instrumental for latency troubleshooting and the implementation of Traffic Engineering (TE) solutions to meet Service Level Agreements (SLAs).

This feature enhances TWAMP functionality in OcNOS, focusing on accuracy and configurable advertisement of the measured data.

Regarding L3VPN scenarios based on SRv6, TWAMP over L3VPN is applicable to the following:

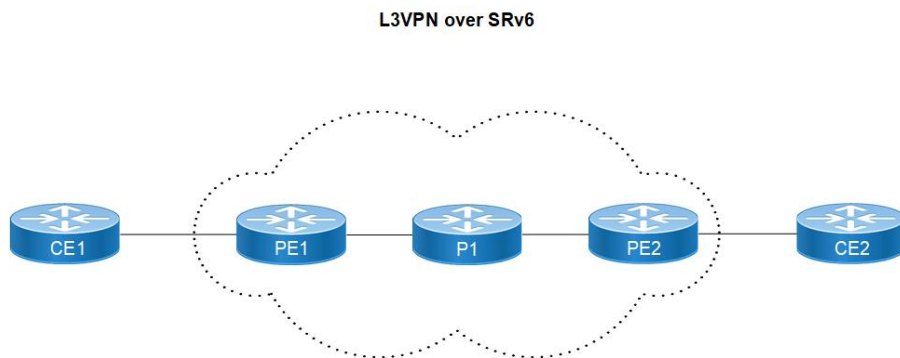
- CE-CE: Overlay Only
- CE-PE: Overlay Only
- PE-PE: Both Underlay and Overlay.

Topology

Below figure displays a sample TWAMP over L3VPN topology.

- CE1 and CE2 are customer edge routers
- PE1 and PE2 are IPv6 Provider Edge routers
- P1 is the router at the core of the SRv6 network.

Figure 44. TWAMP over EVPN-L3VPN Topology



SRv6 Configuration

PE1

SRv6 is configured on PE1 for IGP configs with ISIS v6 and OSPFv3 configuration.

PE1#configure terminal	Enter Configure mode.
PE1(config)#interface lo	Enter interface mode
PE1(config-if)# ip address 1.1.1.1/32 secondary	Assign IP address to interface lo
PE1(config-if)# ipv6 address 1001::1/128	Assign IPv6 address to interface lo
PE1(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
PE1(config-if)# ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#exit	Exit interface mode.
PE1(config-if)#interface ce3	Enter interface mode
PE1(config-if)# load-interval 30	Enable load interval
PE1(config-if)# ipv6 address 1112::1/64	Assign IPv6 address to interface
PE1(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
PE1(config-if)# ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE1(config-if)#exit	Exit interface mode.
PE1(config)#segment-routing	Enable segment routing
PE1(config-sr)# srv6	Segment-Routing over IPv6 Data-Plane
PE1(config-srv6)# locators	Configure SRv6 locators
PE1(config-srv6-loc)# locator PE1_locator	Configure SRv6 locator name
PE1(config-srv6-loc-conf)# prefix 1001::/64	Configure prefix for locator
PE1(config-srv6-loc-conf)# exit-locator	Exit from locator
PE1(config-srv6-loc)# exit-locators	Exit from locators
PE1(config-srv6)# exit-srv6	Exit from srv6 mode
PE1(config-sr)#router ipv6 ospf 1	Entering router ospf.
PE1(config-router)# router-id 1.1.1.1	Configure OSPF router-id.
PE1(config-router)# segment-routing srv6	Enable segment routing srv6
PE1(config-router-srv6)# srv6-locator PE1_locator	Configure srv6 locator name
PE1(config-router-srv6)# exit-srv6	Exit from srv6
PE1(config-router)#!	Return to privilege mode
PE1(config-router)#router isis 1	Set the routing process ID as 1
PE1(config-router)# is-type level-2-only	Configure is-type as level-2
PE1(config-router)# metric-style wide	Configure wide metric-style
PE1(config-router)# net 49.0001.0000.0000.0001.00	Configure Network entity title (NET).
PE1(config-router)# address-family ipv6	Enter Address-family IPv6
PE1(config-router-af)# segment-routing srv6	Enable SRv6 under IPv6 address-family
PE1(config-router-af-srv6)# srv6-locator PE1_	Name to SRv6 locator

locator	
PE1(config-router-af-srv6)# exit-srv6	Exit SRv6 mode
PE1(config-router-af)# exit-address-family	Exit address-family IPv6
PE1(config-router)#commit	commit

P1

SRv6 is configured on P1 for IGP configs with ISIS v6 and OSPFv3 configuration.

P1#configure terminal	Enter Configure mode.
P1(config)#interface lo	Enter interface mode
P1(config-if)# ip address 2.2.2.2/32 secondary	Assign IP address to interface lo
P1(config-if)# ipv6 address 2001::1/128	Assign IPv6 address to interface lo
P1(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
P1(config-if)# ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#exit	Exit interface mode.
P1(config-if)#interface ce3	Enter interface mode
P1(config-if)# load-interval 30	Enable load interval
P1(config-if)# ipv6 address 1112::2/64	Assign IPv6 address to interface
P1(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
P1(config-if)# ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#exit	Exit interface mode.
P1(config-if)#interface ce16	Enter interface mode
P1(config-if)# load-interval 30	Enable load interval
P1(config-if)# ipv6 address 2221::1/64	Assign IPv6 address to interface
P1(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
P1(config-if)# ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
P1(config-if)#exit	Exit interface mode.
P1(config-sr)#router ipv6 ospf 1	Entering router ospf.
P1(config-router)# router-id 2.2.2.2	Configure OSPF router-id.
P1(config-router)#!	Return to privilege mode

P1(config-router)#router isis 1	Set the routing process ID as 1
P1(config-router)# is-type level-2-only	Configure is-type as level-2
P1(config-router)# metric-style wide	Configure wide metric-style
P1(config-router)# net 49.0001.0000.0000.0002.00	Configure Network entity title (NET).
P1(config-router)# address-family ipv6	Enter Address-family IPv6
P1(config-router)#commit	commit

PE2

SRv6 is configured on PE2 for IGP configs with ISIS v6 and OSPFv3 configuration

PE2#configure terminal	Enter Configure mode.
PE2(config)#interface lo	Enter interface mode
PE2(config-if)# ip address 3.3.3.3/32 secondary	Assign IP address to interface lo
PE2(config-if)# ipv6 address 3001::1/128	Assign IPv6 address to interface lo
PE2(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
PE2(config-if)# ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE2(config-if)#exit	Exit interface mode.
PE2(config-if)#interface cel	Enter interface mode
PE2(config-if)# load-interval 30	Enable load interval
PE2(config-if)# ipv6 address 2221::2/64	Assign IPv6 address to interface
PE2(config-if)# ipv6 router ospf area 0.0.0.0 tag 1 instance-id 0	Make the interface part of the router ospf area 0.
PE2(config-if)# ipv6 router isis 1	Make the interface part of the router ISIS 1 instance.
PE2(config-if)#exit	Exit interface mode.
PE2(config)#segment-routing	Enable segment routing
PE2(config-sr)# srv6	Segment-Routing over IPv6 Data-Plane
PE2(config-srv6)# locators	Configure SRv6 locators
PE2(config-srv6-loc)# locator PE2_locator	Configure SRv6 locator name
PE2(config-srv6-loc-conf)# prefix 3001::/64	Configure prefix for locator
PE2(config-srv6-loc-conf)# exit-locator	Exit from locator
PE2(config-srv6-loc)# exit-locators	Exit from locators
PE2(config-srv6)# exit-srv6	Exit from srv6 mode
PE2(config-sr)#router ipv6 ospf 1	Entering router ospf.
PE2(config-router)# router-id 3.3.3.3	Configure OSPF router-id.

PE2(config-router)# segment-routing srv6	Enable segment routing srv6
PE2(config-router-srv6)# srv6-locator PE2_locator	Configure srv6 locator name
PE2(config-router-srv6)# exit-srv6	Exit from srv6
PE2(config-router)#!	Return to privilege mode
PE2(config-router)#router isis 1	Set the routing process ID as 1
PE2(config-router)# is-type level-2-only	Configure is-type as level-2
PE2(config-router)# metric-style wide	Configure wide metric-style
PE2(config-router)# net 49.0001.0000.0000.0003.00	Configure Network entity title (NET).
PE2(config-router)# address-family ipv6	Enter Address-family IPv6
PE2(config-router-af)# segment-routing srv6	Enable SRv6 under IPv6 address-family
PE2(config-router-af-srv6)# srv6-locator PE2_locator	Name to SRv6 locator
PE2(config-router-af-srv6)# exit-srv6	Exit SRv6 mode
PE2(config-router-af)# exit-address-family	Exit address-family IPv6
PE2(config-router)#commit	commit

Configure L3VPN

PE1

The following are the step-by-step configurations on the PE1 router.

PE1#configure terminal	Enter Configure mode.
PE1(config)# ip vrf vrf111	Create a new VRF named vrf111
PE1(config-vrf)#rd 10:111	Assign the route distinguisher (RD) value as 10:111
PE1(config-vrf)#route-target both 10:111	Import routes between route target (RT) ext-communities 10 and 111
PE1(config-vrf)#exit	Exit VRF mode
PE1(config)#int xe9	Enter Interface mode
PE1(config-if)#mtu 9216	Set the mtu size
PE1(config-if)#exit	Exit Interface mode
PE1(config-if)#interface xe9.111	Enter Interface mode
PE1(config-if)#encapsulation dot1q 111	Configure encapsulation under a subinterface
PE1(config-if)#ip vrf forwarding vrf111	Bind the interface connected to the CE1 router with VRF 111
PE1(config-if)#ip address 100.1.1.1/24	Assign IP address to interface

PE1(config-if)#mtu 9216	Set the mtu size
PE1(config-if)#exit	Exit
PE1(config)#router bgp 65010	Enter BGP router mode
PE1(config-router)# bgp router-id 1.1.1.1	Configure BGP router-id
PE1(config-router)# neighbor 3001::1 remote-as 65010	Configure neighbor remote-as 65010
PE1(config-router)# neighbor 3001::1 update-source lo	Configure neighbor with update-source lo
PE1(config-router)# address-family vpnv4 unicast	address-family vpnv4 unicast
PE1(config-router-af)# segment-routing srv6	Enter SRv6 mode
PE1(config-router-vpnv4-srv6)# srv6-locator PE1_locator	Configure locator name under SRv6 mode
PE1(config-router-vpnv4-srv6)# exit-srv6	Exit SRv6 mode
PE1(config-router-af)# neighbor 3001::1 activate	Activate VPNv4 neighbor
PE1(config-router-af)# neighbor 3001::1 capability extended-nexthop-encode	Configure extended nexthop encode capability for VPNv4 neighbor
PE1(config-router-af)# exit-address-family	Exit from Address Family configuration mode
PE1(config-router)# address-family ipv4 vrf vrf111	Enter VRF address family
PE1(config-router-af)# redistribute connected	Redistribute connected routes
PE1(config-router-af)# segment-routing srv6	Enter SRv6 mode
PE1(config-router-vrfv4-srv6)# sid-alloc per-vrf	Allocate SID per VRF
PE1(config-router-vrfv4-srv6)# exit-srv6	Exit SRv6 mode
PE1(config-router-af)# neighbor 100.1.1.2 remote-as 100	Configure EBGP neighbor remote-as 100
PE1(config-router-af)# neighbor 100.1.1.2 activate	Configure EBGP neighbor activate
PE1(config-router-af)# exit-address-family	Exit from Address Family configuration mode
PE1(config-router-af)# commit	commit

PE2

The following are the step-by-step configurations on the PE2 router.

PE2#configure terminal	Enter Configure mode.
PE2(config)# ip vrf vrf111	Create a new VRF named vrf111
PE2(config-vrf)#rd 10:111	Assign the route distinguisher (RD) value as 10:111
PE2(config-vrf)#route-target both 10:111	Import routes between route target (RT) ext-

	communities 10 and 111
PE2(config-vrf)#exit	Exit VRF mode
PE2(config)#int xe9	Enter Interface mode
PE2(config-if)#mtu 9216	Set the mtu size
PE2(config-if)#exit	Exit Interface mode
PE2(config-if)#interface xe4.111	Enter Interface mode
PE2(config-if)#encapsulation dot1q 111	Configure encapsulation under a subinterface
PE2(config-if)#ip vrf forwarding vrf111	Bind the interface connected to the CE1 router with VRF 111
PE2(config-if)#ip address 200.1.1.1/24	Assign IP address to interface
PE2(config-if)#mtu 9216	Set the mtu size
PE2(config-if)#exit	Exit
PE2(config)#router bgp 65010	Enter BGP router mode
PE2(config-router)# bgp router-id 3.3.3.3	Configure BGP router-id
PE2(config-router)# neighbor 1001::1 remote-as 65010	Configure neighbor remote-as 65010
PE2(config-router)# neighbor 1001::1 update-source lo	Configure neighbor with update-source lo
PE2(config-router)# address-family vpnv4 unicast	address-family vpnv4 unicast
PE2(config-router-af)# segment-routing srv6	Enter SRv6 mode
PE2(config-router-vpnv4-srv6)# srv6-locator PE2_locator	Configure locator name under SRv6 mode
PE2(config-router-vpnv4-srv6)# exit-srv6	Exit SRv6 mode
PE2(config-router-af)# neighbor 1001::1 activate	Activate VPNv4 neighbor
PE2(config-router-af)# neighbor 1001::1 capability extended-nexthop-encode	Configure extended nexthop encode capability for VPNv4 neighbor
PE2(config-router-af)# exit-address-family	Exit from Address Family configuration mode
PE2(config-router)# address-family ipv4 vrf vrf111	Enter VRF address family
PE2(config-router-af)# redistribute connected	Redistribute connected routes
PE2(config-router-af)# segment-routing srv6	Enter SRv6 mode
PE2(config-router-vrfv4-srv6)# sid-alloc per-vrf	Allocate SID per VRF
PE2(config-router-vrfv4-srv6)# exit-srv6	Exit SRv6 mode
PE2(config-router-af)# neighbor 200.1.1.2 remote-as 100	Configure EBGP neighbor remote-as 100
PE2(config-router-af)# neighbor 200.1.1.2 activate	Configure EBGP neighbor activate
PE2(config-router-af)# exit-address-family	Exit from Address Family configuration mode
PE2(config-router-af)# commit	commit

CE1

The following are the step-by-step configurations on the CE1 router.

#configure terminal	Enter Configure mode.
(config)#int xe6	Enter Interface mode
(config-if)#mtu 9216	Set the mtu size
(config-if)#interface xe6.111	Enter Interface mode
(config-if)#encapsulation dot1q 111	Configure encapsulation under a subinterface
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 100.1.1.2/24	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#interface lo	Configure lo interface
(config-if)#ip address 11.11.11.11/32 secondary	Assign IP address to interface
(config-if)#router bgp 100	Enter BGP router mode
(config-router)#neighbor 100.1.1.1 remote-as 65010	Configure BGP router-id
(config-router)#address-family ipv4 unicast	Enter address-family vpnv4 mode
(config-router-af)#neighbor 100.1.1.1 activate	mode Activate neighbor
(config-router-af)#redistribute connected	Redistribute connected routes
(config-router-af)#commit	Commit the configurations
(config-router-af)#end	Return to privilege mode

CE2

The following are the step-by-step configurations on the CE2 router.

#configure terminal	Enter Configure mode.
(config)#int xe4	Enter Interface mode
(config)#mtu 9216	Set the mtu size
(config)#interface xe4.111	Enter Interface mode
(config)#encapsulation dot1q 111	Configure encapsulation under a subinterface
(config)#load-interval 30	Enable load interval
(config)#ip address 200.1.1.2/24	Assign IP address to interface
(config)#mtu 9216	Set the mtu size
(config-if)#interface lo	Configure lo interface
(config-if)#ip address 22.22.22.22/32 secondary	Assign IP address to interface
(config-if)#router bgp 200	Enter BGP router mode
config-router)#neighbor 200.1.1.1 remote-as 65010	Configure BGP router-id

config-router-af)#address-family ipv4 unicast	Enter address-family ipv4 mode
config-router-af)#neighbor 200.1.1.1 activate	mode Activate neighbor
config-router-af)#redistribute connected	Redistribute connected routes
(config)#commit	Commit the configurations
(config)#end	Return to privilege mode

TWAMP Between CE1 and CE2

TWAMP Configuration on Sender (CE1)

TWAMP sender is configured to measure the delay on interface Loopback on CE1

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP meas- urement configs
(config)#commit	Commit the configuration
(config)# twamp-light control	Enable TWAMP light controller on CE1
(config-twamp-light-ctrl)# control-admin- state enable	Enable TWAMP Controller admin state
(config-twamp-light-ctrl)#delay-profile interfaces	Enter in to delay profile mode
(config-dp-intf)#mode two-way	Enter mode
(config-dp-intf)#burst-count 1	Enter burst count
(config-dp-intf)#burst-interval 1000	Configure burst interval value under delay profile mode
(config-dp-intf)#interval 30	Configure interval
(config-dp-intf)#advertisement periodic threshold 10	Configure advertisement periodic
(config-dp-intf)#advertisement periodic minimum-change 1000	Configure advertisement periodic minimum
(config-dp-intf)#advertisement accelerated	Configure advertisement accelerated
(config-dp-intf)#advertisement accelerated threshold 20	Configure advertisement accelerated threshold
(config-dp-intf)#advertisement accelerated minimum-change 2000	Configure advertisement accelerated minimum
(config-dp-intf)#int lo	Enter Interface Loopback mode
(config-if)#loss-measurement dynamic	Configure loss measurement
(config-if)#delay-measurement dynamic twamp reflector-ip 22.22.22.22 sender-ip 11.11.11.11	Enter in to delay profile mode
(config-if)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

TWAMP Configuration on Reflector (CE2)

Configure TWAMP Reflector as interface xe4 on CE2 (Towards core)

#configure terminal	Enter Configure mode
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP measurement configuration
(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 CE2-CE1-lo reflector-ip ipv4 22.22.22.22	Configure TWAMP reflector IP as CE2 interface IP
(config-twamp-light-ref)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

Validation

L3VPN over SRv6 Validation

Verify MP-BGP VPNv4 neighbourship

```

PE1#show ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 65010
BGP table version is 3
3 BGP AS-PATH entries
0 BGP community entries

Neighbor          V    AS  MsgRcv  MsgSen  TblVer   InQ   OutQ   Up/Down   State/PfxRcd
3001::1           4  65010   282     281      3      0      0   01:58:45         2

Total number of neighbors 1

Total number of Established sessions 1

BGP VRF vrf111 Route Distinguisher: 10:111
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
100.1.1.2         4   100   284     285      1      0      0   01:58:50         2

Total number of neighbors 1

Total number of Established sessions 1
PE1#
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: 10:111 (Default for VRF vrf111)
*>  11.11.11.0/24    100.1.1.2             0         100        0  100 ?
*>i  22.22.22.22/32   3001::1                0         100        0  200 ?

```

```
*> 100.1.1.0/24 0.0.0.0 0 100 32768 ?
* 100.1.1.2 0 100 0 100 ?
*>i 200.1.1.0 3001::1 0 100 0 ?
Announced routes count = 3
Accepted routes count = 2
Route Distinguisher: 10:111
*>i 22.22.22.22/32 3001::1 0 100 0 200 ?
*>i 200.1.1.0 3001::1 0 100 0 ?
Announced routes count = 0
Accepted routes count = 2
PE1#show segment-routing srv6 sid
SRv6 Segment ID table:
SID Operation Nexthop Originator
+-----+-----+-----+-----+
1001::801:0:0:0 END[usd] :: nsm
1001::1001:0:0:0 END[usp] :: nsm
1001::2001:0:0:0 END[psp] :: nsm
1001::6001:0:0:0 END.X[psp] fe80::eac5:7aff:feba:f18 isis
1001::8001:0:0:0 END.DT4 vrf vrf111 bgp:65010
```

PE1

Verify show SRv6 mpls services

```
PE1#show segment-routing srv6 services
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
L3VPN:
Service Flags
vrf FEC SID Nexthop SRv6-
Policy-Name
vpn4 > vrf111 200.1.1.0/24 3001::8001:0:0:0 3001::1
None
vpn4 > vrf111 22.22.22.22/32 3001::8001:0:0:0 3001::1
None
```

TWAMP CE1 to CE2 Validation

CE1

Verify ping between CE1 lo to CE2 lo

```
CE1#ping 22.22.22.22
Press CTRL+C to exit
PING 22.22.22.22 (22.22.22.22) 56(84) bytes of data.
64 bytes from 22.22.22.22: icmp_seq=1 ttl=126 time=0.483 ms
64 bytes from 22.22.22.22: icmp_seq=2 ttl=126 time=0.449 ms
64 bytes from 22.22.22.22: icmp_seq=3 ttl=126 time=0.421 ms

--- 22.22.22.22 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 1000ms
rtt min/avg/max/mdev = 0.421/0.451/0.483/0.025 ms
```

CE1

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.

```
CE1#show twamp-statistics
=====
TWAMP Test-Session Statistics
```

```

=====
Test-Session Name      : __internal_interface_lo
Start Time             : 2023 Oct 19 10:48:15
Elapsed time(milli sec) : 330207
Packets Sent           : 330
Packets Received       : 330
Packet Loss(%)         : 0.00
Round Trip Delay(usec)
  Minimum              : 38
  Maximum              : 49
  Average              : 39
Forward Delay(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Reverse Delay(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Round Trip Delay Variation(usec)
  Minimum              : 15
  Maximum              : 39
  Average              : 15
Forward Delay Variation(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)
Reverse Delay Variation(usec)
  Minimum              : (*)
  Maximum              : (*)
  Average              : (*)

(*) - Time is not in sync between Sender and Reflector

```

CE1

show twamp-statistics interfaces

```

CE1#show twamp-statistics interfaces
Interface Last Advertisement Delay(us) Min(us) Max(us) Var(us) Loss(%)
lo 2023-10-19 10:54:02 20 20 23 0 0.00

```

CE1

Verify the Detailed list of TWAMP delay measurement information on CE lo interface

```

CE1#show twamp-statistics interfaces lo
Interface name      : lo
Sender IP          : 11.11.11.11
Reflector IP       : 22.22.22.22
Reflector port     : 862
DSCP value         : 0
HW Status          : HW rules installed
Last Advertised stats:
  Time: 2023-10-19 10:54:02
  Average delay      : 20
  Minimum delay      : 20
  Maximum delay      : 23
  Average delay variation: 0
  Minimum delay variation: 0
  Maximum delay variation: 0
  Packets sent       : 21
  Packets received    : 21
  Packets timeout     : 0
  Packet Loss: 0.00

```

```
Last Calculated stats:
Time: 2023-10-19 10:54:02
Average delay      : 20
Minimum delay      : 20
Maximum delay      : 23
Average delay variation: 0
Minimum delay variation: 0
Maximum delay variation: 0
Packets sent       : 21
Packets received    : 21
Packets timeout     : 0
Packet Loss : 0.00
```

TWAMP over L3VPN with SR

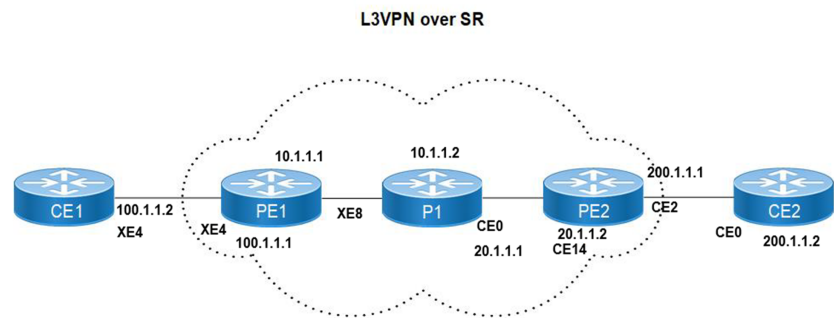
The Two-way Active Measurement Protocol (TWAMP) over Layer 3 Virtual Private Network (L3VPN) with Segment Routing (SR) feature enables efficient network performance measurement in complex network environments. TWAMP is an open standard protocol for measuring network performance between any two devices, and this feature extends its capabilities to L3VPN networks with SR. This feature enables the measurement and monitoring of service quality and reliability within L3VPN networks. This feature enables a comprehensive analysis of essential network performance metrics, including latency, packet loss, and various performance metrics.

Topology

Below figure 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 45. TWAMP over L3VPN Topology



SR-MPLS Configuration

PE1

SR-MPLS is configured on PE1 for IGP configs with ISIS and OSPF configuration.

#configure terminal	Enter Configure mode
(config)#int lo	Enter interface mode
(config-if)#ip add 1.1.1.1/32 secondary	Assign IP address to interface
(config-if)#prefix-sid index 100 no-php	Configure sid value with no-php
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#interface xe8	Enter Interface mode
(config-if)#load-interval 30	Enable load interval

(config-if)#ip address 10.1.1.1/30	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching.
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-router)#router isis 1	Set the routing process ID
(config-router)#is-type level-2-only	Configure isis level2
(config-router)#metric-style wide	Configure Network entity title (NET).
(config-router)#mpls traffic-eng router-id 1.1.1.1	Enable mpls traffic eng router-id
(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
(config-router)#capability cspf	Enable capability cspf
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#net 49.0001.0000.0001.0011.00	Configure network.
(config-router)#isis segment-routing global block20000 23000	Enable SRGB range under ISIS process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#router ospf 1	Entering router ospf.
(config-router)#ospf router-id 1.1.1.1	Configure OSPF router-id
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#network 1.1.1.1/32 area 0.0.0.0	Configure network.
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Configure network.
(config-router)#ospf segment-routing global block	Enable SRGB range under OSPF process
16000 19000	
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

P1

SR-MPLS is configured on P1 for IGP configs with ISIS and OSPF configuration.

#configure terminal	Enter Configure mode
(config)#int lo	Enter interface mode
(config-if)#ip add 2.2.2.2/32 secondary	Assign IP address to interface

(config-if)#prefix-sid index 200 no-php	Configure sid value with no-php
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#interface xe8	Enter interface mode
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 10.1.1.2/30	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching.
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#interface ce0	Enter interface mode
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 20.1.1.1/30	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching.
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#router isis 1	Set the routing process ID
(config-router)#is-type level-2-only	Configure isis level2
(config-router)#metric-style wide	Configure Network entity title (NET).
(config-router)#mpls traffic-eng router-id 2.2.2.2	Enable mpls traffic eng router-id
(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
(config-router)#capability cspf	Enable capability cspf
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#net 49.0001.0000.0001.0022.00	Configure network.
(config-router)#isis segment-routing global block20000 23000	Enable SRGB range under ISIS process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#router ospf 1	Entering router ospf.
(config-router)#ospf router-id 2.2.2.2	Configure OSPF router-id.
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#network 2.2.2.2/32 area 0.0.0.0	Configures a network with the IP address 2.2.2.2 as a part of OSPF area 0.0.0.0 in a router's configuration
(config-router)#network 10.1.1.0/24 area 0.0.0.0	Configures a network with the IP address 10.1.1.0 as a part of OSPF area 0.0.0.0 in a router's

	configuration.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Configures a network with the IP address 20.1.1.0 as a part of OSPF area 0.0.0.0 in a router's configuration.
(config-router)#ospf segment-routing global block 16000 19000	Enable SRGB range under OSPF process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

PE2

SR-MPLS is configured on PE2 for IGP configs with ISIS and OSPF configuration.

#configure terminal	Enter Configure mode
(config)#int lo	Enter interface mode
(config-if)#ip add 3.3.3.3/32 secondary	Assign IP address to interface
(config-if)#prefix-sid index 300 no-php	Configure sid value with no-php
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance
(config-if)#interface cel4	Enter interface mode
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 20.1.1.2/30	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#label-switching	Enable label switching
(config-if)#ip ospf network point-to-point	Enable network as point to point
(config-if)#isis network point-to-point	Enable network as point to point
(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
(config-if)#route isis 1	Set the routing process ID
(config-router)#is-type level-2-only	Configure isis level2
(config-router)#metric-style wide	Configure Network entity title (NET).
(config-router)#mpls traffic-eng router-id 3.3.3.3	Enable mpls traffic eng router-id
(config-router)#mpls traffic-eng level-2	Enable MPLS Traffic Engineering as level-2
(config-router)#capability cspf	Enable capability cspf
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#net 49.0001.0000.0001.0033.00	Configures a network with the address 49.0001.0000.0001.0033.00 in a ISIS configuration
(config-router)#isis segment-routing global block 20000 23000	Enable SRGB range under ISIS process

(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#router ospf 1	Entering router ospf.
(config-router)#ospf router-id 3.3.3.3	Configure OSPF router-id.
(config-router)#bfd all-interfaces	Enable bfd all interfaces
(config-router)#network 3.3.3.3/32 area 0.0.0.0	Configures a network with the IP address 3.3.3.3 as a part of OSPF area 0.0.0.0 in a router's configuration.
(config-router)#network 20.1.1.0/24 area 0.0.0.0	Configures a network with the IP address 20.1.1.0 as a part of OSPF area 0.0.0.0 in a router's configuration.
(config-router)#ospf segment-routing global block 16000 19000	Enable SRGB range under OSPF process
(config-router)#segment-routing mpls	Enable segment routing mpls ISIS process.
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

Configure L3VPN

PE1

The following are the step-by-step configurations on the PE1 router.

#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)#l3vni 1000	L3 Virtual Network Identifier
(config-vrf)#exit	Exit VRF mode
(config)#interface xe4	Enter Interface mode
(config-if)#mtu 9216	Set the mtu size
(config-if)#exit	Exit Interface mode
(config-if)#interface xe4.100	Enter Interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(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)#mtu 9216	Set the mtu size
(config-if)#exit	Exit

(config)#router bgp 65010	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 65010	Configure PE2 as an iBGP4+ neighbor
(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 unicast	address-family vpnv4 unicast
(config-router-af)#neighbor 3.3.3.3 activate	Activate the PE1 neighbor in the vpnv4 address family
(config-router-af)#exit-address-family	Exit
(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 100	Configure CE2 neighbor in the vrf address family
(config-router-af)#neighbor 100.1.1.2 activate	Activate the CE2 neighbor
(config-router-af)#exit-address-family	Exit form address family
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

PE2

The following are the step-by-step configurations on the PE2 router.

#configure terminal	Enter Configure mode.
(config)#ip vrf vrf100	Create a new VRF named vrf100
(config-vrf)#rd 10:100	Assign the route distinguisher (RD) value as 10:100
(config-vrf)#route-target both 100:1	Import routes between RT ext-communities 100 and 1
(config-vrf)#l3vni 1000	L3 Virtual Network Identifier
(config-vrf)#exit	Exit VRF mode
(config)#interface ce2	Enter Interface mode
(config-if)#mtu 9216	Set the mtu size
(config-if)#interface ce2.100	Enter Interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#ip vrf forwarding vrf100	Bind the interface connected to the CE1 router with VRF 100
(config-if)#ip address 200.1.1.1/24	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config)#router bgp 65010	Enter BGP router mode

(config-router)#bgp router-id 3.3.3.3	Configure BGP router-id
(config-router)#neighbor 1.1.1.1 update-source lo	Configure PE2 as an iBGP4+ neighbor
(config-router)#neighbor 1.1.1.1 remote-as 65010	Update the source as loopback for iBGP peering with the remote PE2 router
(config-router)#address-family vpnv4 unicast	address-family vpnv4 unicast
(config-router-af)#neighbor 1.1.1.1 activate	Activate the PE1 neighbor in the vpnv4 address family
(config-router-af)#exit-address-family	Exit
(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 200.1.1.2 remote-as 200	Configure CE2 neighbor in the vrf address family
(config-router-af)#neighbor 200.1.1.2 activate	Activate the CE2 neighbor
(config-router-af)#exit-address-family	Exit form address family
(config-router)#commit	Commit the configurations
(config-router)#end	Return to privilege mode

CE1

The following are the step-by-step configurations on the CE1 router.

#configure terminal	Enter Configure mode.
(config)#int xe4	Enter Interface mode
(config-if)#mtu 9216	Set the mtu size
(config-if)#interface xe4.100	Enter Interface mode
(config-if)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config-if)#load-interval 30	Enable load interval
(config-if)#ip address 100.1.1.2/24	Assign IP address to interface
(config-if)#mtu 9216	Set the mtu size
(config-if)#interface lo	Configure lo interface
(config-if)#ip address 11.11.11.11/32 secondary	Assign IP address to interface
(config-if)#router bgp 100	Enter BGP router mode
(config-router)#neighbor 100.1.1.1 remote-as 65010	Configure BGP router-id
(config-router)#address-family ipv4 unicast	Enter address-family vpnv4 mode
(config-router-af)#neighbor 100.1.1.1 activate	mode Activate neighbor
(config-router-af)#redistribute connected	Redistribute connected routes
(config-router-af)#commit	Commit the configurations
(config-router-af)#end	Return to privilege mode

CE2

The following are the step-by-step configurations on the CE2 router.

#configure terminal	Enter Configure mode.
(config)#int ce0	Enter Interface mode
(config)#mtu 9216	Set the mtu size
(config)#interface ce0.100	Enter Interface mode
(config)#encapsulation dot1q 100	Configure encapsulation under a subinterface
(config)#load-interval 30	Enable load interval
(config)#ip address 200.1.1.2/24	Assign IP address to interface
(config)#mtu 9216	Set the mtu size
(config-if)#interface lo	Configure lo interface
(config-if)#ip address 22.22.22.22/32 secondary	Assign IP address to interface
(config-if)#router bgp 200	Enter BGP router mode
config-router)#neighbor 200.1.1.1 remote-as 65010	Configure BGP router-id
config-router-af)#address-family ipv4 unicast	Enter address-family ipv4 mode
config-router-af)#neighbor 200.1.1.1 activate	mode Activate neighbor
config-router-af)#redistribute connected	Redistribute connected routes
(config)#commit	Commit the configurations
(config)#end	Return to privilege mode

TWAMP Configuration Between CE1 and CE2

TWAMP Configuration on Sender (CE1)

TWAMP sender is configured to measure the delay on interface Loopback on 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 PE1
(config-twamp-light-ctrl)# control-admin-state enable	Enable TWAMP Controller admin state
(config-twamp-light-ctrl)#delay-profile interfaces	Enter in to delay profile mode
(config-dp-intf)#mode two-way	Enter mode
(config-dp-intf)#burst-count 1	Enter burst count
(config-dp-intf)#burst-interval 1000	Configure burst interval value under delay profile mode

(config-dp-intf)#interval 30	Configure interval
(config-dp-intf)#advertisement periodic threshold 10	Configure advertisement periodic
(config-dp-intf)#advertisement periodic minimum-change 1000	Configure advertisement periodic minimum change
(config-dp-intf)#advertisement accelerated	Configure advertisement accelerated
(config-dp-intf)#advertisement accelerated threshold 20	Configure advertisement accelerated threshold
(config-dp-intf)#advertisement accelerated minimum-change 2000	Configure advertisement accelerated minimum change
(config-dp-intf)#int lo	Enter Interface Loopback mode
(config-if)#loss-measurement dynamic	Configure loss measurement
(config-if)#delay-measurement dynamic twamp reflector-ip 22.22.22.22 sender-ip 11.11.11.11	Enter in to delay profile mode
(config-if)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

TWAMP Configuration on Reflector (CE2)

Configure TWAMP Reflector as interface CE0 on CE2 (Towards core).

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP meas- urement 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 CE2-CE1-lo reflector-ip ipv4 22.22.22.22	Configure TWAMP reflector IP as PE2 interface IP
(config-twamp-light-ref)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

TWAMP Configuration Between CE1 and PE2

TWAMP Configuration on Source (CE1)

TWAMP sender is configured to measure the delay on access interface on CE1.

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure TWAMP meas- urement configs

(config)#commit	Commit the configuration
(config)# twamp-light control	Enable TWAMP light controller on CE1
(config-twamp-light-ctrl)# control-admin- state enable	Enable TWAMP Controller admin state
(config-twamp-light-ctrl)#delay-profile interfaces	Enter in to delay profile mode
(config-dp-intf)#mode two-way	Enter mode
(config-dp-intf)#burst-count 1	Enter burst count
(config-dp-intf)#burst-interval 1000	Configure burst interval value under delay profile mode
(config-dp-intf)#interval 30	Configure interval
(config-dp-intf)#advertisement periodic threshold 10	Configure advertisement periodic
(config-dp-intf)#advertisement periodic minimum-change 1000	Configure advertisement periodic minimum change
(config-dp-intf)#advertisement accelerated	Configure advertisement accelerated
(config-dp-intf)#advertisement accelerated threshold 20	Configure advertisement accelerated threshold
(config-dp-intf)#advertisement accelerated minimum-change 2000	Configure advertisement accelerated minimum change
(config-dp-intf)# int xe4.100	Enter Interface Loopback mode
(config-if)#loss-measurement dynamic	Configure loss measurement
(config-if)# delay-measurement dynamic twamp reflector-ip 200.1.1.1 sender-ip 100.1.1.2	Configure delay measurement on the interface
(config-if)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

TWAMP Configuration on Reflector (PE2)

Configure TWAMP Reflector as access interface on PE2.

#configure terminal	Enter Configure mode.
(config)# hardware-profile filter twamp-ipv4 enable	Enable hardware filter for ipv4 to configure measurement configurations
(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 RTR1-lo reflector-ip ipv4 200.1.1.1 vrf vrf100	Configure TWAMP reflector IP as PE2 interface IP
(config-twamp-light-ref)#commit	Commit the configurations
(config-if)#end	Return to privilege mode

Validation

L3VPN over SR VALIDATION

Verify MP-BGP VPNv4 neighbourship

```
PE1#show ip bgp vpnv4 all summary
BGP router identifier 1.1.1.1, local AS number 65010
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
3.3.3.3            4  65010   19      17      4      0      0   00:04:18      2

Total number of neighbors 1

Total number of Established sessions 1

BGP VRF vrf100 Route Distinguisher: 10:100
BGP table version is 2
3 BGP AS-PATH entries
0 BGP community entries

Neighbor          V    AS  MsgRcv  MsgSen  TblVer  InQ   OutQ   Up/Down  State/PfxRcd
100.1.1.2          4   100   13      18      2      0      0   00:04:47      2

Total number of neighbors 1

Total number of Established sessions 1
PE1#
```

Verify show mpls vrf-forwarding table

```
PE1#sh 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>   22.22.22.22/32    2        0         Yes  LSP_DEFAULT  28800      -
        3.3.3.3
  B>   200.1.1.0/24     1        0         Yes  LSP_DEFAULT  28800      -
        3.3.3.3
PE1#
```

Verify mpls l3vpn ping

```
PE1#ping mpls l3vpn vrf100 200.1.1.0/24 detail
Sending 5 MPLS Echos to 200.1.1.0, 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
```

```

! seq_num = 1 20.1.1.2 0.86 ms
! seq_num = 2 20.1.1.2 0.62 ms
! seq_num = 3 20.1.1.2 0.48 ms
! seq_num = 4 20.1.1.2 0.48 ms
! seq_num = 5 20.1.1.2 0.54 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.48/0.67/0.86
PE1#
PE1#ping mpls l3vpn vrf100 22.22.22.22/32 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 20.1.1.2 0.72 ms
! seq_num = 2 20.1.1.2 0.54 ms
! seq_num = 3 20.1.1.2 0.51 ms
! seq_num = 4 20.1.1.2 0.52 ms
! seq_num = 5 20.1.1.2 0.47 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.47/0.60/0.72

```

CE1 to CE2 TWAMP VALIDATION

Verify ping between CE1 lo to CE2 lo

```

CE1#ping 22.22.22.22
Press CTRL+C to exit
PING 22.22.22.22 (22.22.22.22) 56(84) bytes of data.
64 bytes from 22.22.22.22: icmp_seq=1 ttl=62 time=0.564 ms
64 bytes from 22.22.22.22: icmp_seq=2 ttl=62 time=0.426 ms
64 bytes from 22.22.22.22: icmp_seq=3 ttl=62 time=0.848 ms

--- 22.22.22.22 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 6lms
rtt min/avg/max/mdev = 0.426/0.612/0.848/0.177 ms

```

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.

```

CE1#show twamp-statistics
=====
TWAMP Test-Session Statistics
=====
Test-Session Name      : __internal_interface_lo
Start Time             : 2023 Oct 16 22:59:07
Elapsed time(milli sec) : 16008
Packets Sent           : 16
Packets Received       : 16
Packet Loss(%)         : 0.00
Round Trip Delay(usec)

```

```

Minimum          : 277
Maximum          : 595
Average          : 387
Forward Delay(usec)
Minimum          : (*)
Maximum          : (*)
Average          : (*)
Reverse Delay(usec)
Minimum          : (*)
Maximum          : (*)
Average          : (*)
Round Trip Delay Variation(usec)
Minimum          : 220
Maximum          : 406
Average          : 300
Forward Delay Variation(usec)
Minimum          : (*)
Maximum          : (*)
Average          : (*)
Reverse Delay Variation(usec)
Minimum          : (*)
Maximum          : (*)
Average          : (*)

(*) - Time is not in sync between Sender and Reflector

```

show twamp-statistics interfaces

```

CE1#sh twamp-statistics interfaces
Interface  Last Advertisement  Delay(us)  Min(us)  Max(us)  Var(us)  Loss(%)
lo 2023-10-16 23:00:52    148      148      148        0      0.00

```

Verify the Detailed list of TWAMP delay measurement information on CE lo interface

```

CE1#sh twamp-statistics interfaces lo
Interface name      : lo
Sender IP           : 11.11.11.11
Reflector IP        : 22.22.22.22
Reflector port      : 862
DSCP value          : 0
HW Status           : -
Last Advertised stats:
Time: 2023-10-16 23:01:12
Average delay       : 145
Minimum delay       : 106
Maximum delay       : 165
Average delay variation: 3
Minimum delay variation: 2
Maximum delay variation: 6
Packets sent        : 13
Packets received    : 13
Packets timeout     : 0
Packet Loss: 0.00
Last Calculated stats:
Time: 2023-10-16 23:01:12
Average delay       : 145
Minimum delay       : 106
Maximum delay       : 165
Average delay variation: 3
Minimum delay variation: 2
Maximum delay variation: 6
Packets sent        : 13
Packets received    : 13
Packets timeout     : 0
Packet Loss : 0.00

```

CE1 to PE2 TWAMP VALIDATION

Verify ping between CE1 lo to PE2

```
OcNOS#ping 200.1.1.1 source-ip 100.1.1.2
Press CTRL+C to exit
PING 200.1.1.1 (200.1.1.1) from 100.1.1.2 : 56(84) bytes of data.
64 bytes from 200.1.1.1: icmp_seq=1 ttl=63 time=0.969 ms
64 bytes from 200.1.1.1: icmp_seq=2 ttl=63 time=0.486 ms
64 bytes from 200.1.1.1: icmp_seq=3 ttl=63 time=0.456 ms
64 bytes from 200.1.1.1: icmp_seq=4 ttl=63 time=0.480 ms

--- 200.1.1.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 53ms
rtt min/avg/max/mdev = 0.456/0.597/0.969/0.216 ms
```

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.

```
CE1#show twamp-statistics
=====
TWAMP Test-Session Statistics
=====
Test-Session Name       : __internal_interface_xe4.100
Start Time              : 2019 Feb 21 16:53:02
Elapsed time(milli sec) : 56038
Packets Sent            : 56
Packets Received        : 56
Packet Loss(%)          : 0.00
Round Trip Delay(usec)
  Minimum               : 12
  Maximum               : 14
  Average               : 12
Forward Delay(usec)
  Minimum               : (*)
  Maximum               : (*)
  Average               : (*)
Reverse Delay(usec)
  Minimum               : (*)
  Maximum               : (*)
  Average               : (*)
Round Trip Delay Variation(usec)
  Minimum               : 12
  Maximum               : 12
  Average               : 12
Forward Delay Variation(usec)
  Minimum               : (*)
  Maximum               : (*)
  Average               : (*)
Reverse Delay Variation(usec)
  Minimum               : (*)
  Maximum               : (*)
  Average               : (*)

(*) - Time is not in sync between Sender and Reflector
```

show twamp-statistics interfaces

```
OcNOS# show twamp-statistics interfaces
Interface Last Advertisement Delay(us) Min(us) Max(us) Var(us) Loss(%)
xe4.100 2019-02-21 23:11:42 7 7 7 0 0.00
```

Verify the Detailed list of TWAMP delay measurement information on CE1 interface

```
OcNOS# show twamp-statistics interfaces xe4.100
Interface name      : xe4.100
Sender IP           : 100.1.1.2
Reflector IP        : 200.1.1.1
Reflector port      : 862
DSCP value          : 0
HW Status           : HW rules installed
Last Advertised stats:
  Time: 2019-02-21 23:11:42
  Average delay      : 7
  Minimum delay      : 7
  Maximum delay      : 7
  Average delay variation: 0
  Minimum delay variation: 0
  Maximum delay variation: 0
  Packets sent       : 1
  Packets received   : 1
  Packets timeout    : 0
  Packet Loss: 0.00
Last Calculated stats:
  Time: 2019-02-21 23:19:12
  Average delay      : 7
  Minimum delay      : 6
  Maximum delay      : 7
  Average delay variation: 0
  Minimum delay variation: 0
  Maximum delay variation: 0
  Packets sent       : 30
  Packets received   : 30
  Packets timeout    : 0
  Packet Loss : 0.00
```

Entropy Labels for ISIS or OSPF Segment Routing

Overview

The Entropy feature, which involves integrating Entropy Labels into ISIS or OSPF Segment Routing, aims to enhance load balancing, path distribution, and overall network efficiency.

Feature Characteristics

The Entropy Label feature has the following advantages for optimized traffic distribution:

- At the source node, the Entropy label is added into the ISIS or OSPF Segment Routing framework. This ensures load-balancing and even traffic distribution across available Link Aggregation Groups (LAG) paths.
- Intermediate routers in the network utilize the Entropy label to perform a hash calculation on the packet's header fields. The hashing mechanism (fields) used, is hardware-dependent. To enable entropy label functionality, the hashing mechanism must encompass the MPLS header. The calculated hash value determines the optimal LAG path for the packet to follow.
- Entropy Labels lead to the better utilization of the available network routes.
- Entropy Labels enables dynamic traffic distribution, leading to more balanced network resource utilization.

Benefits

The Entropy Label feature has the following benefits:

- Optimizes traffic distribution and load balancing, resulting in improved network performance and reduced latency.
- Evenly distributes traffic and reduces congestion on specific links.
- Introduces path diversity, allowing ISIS or OSPF Segment Routing to leverage a wider range of routing options for efficient traffic distribution.
- The dynamic traffic distribution achieved through Entropy Labels reduces the need for manual traffic engineering, simplifying network management.
- Enhances the scalability of ISIS or OSPF Segment Routing by enabling efficient utilization of multiple available paths.

Prerequisites

- Ensure that the network devices and routers used support Entropy Label functionality.
- The network must already have MPLS configured and operational.

Topology

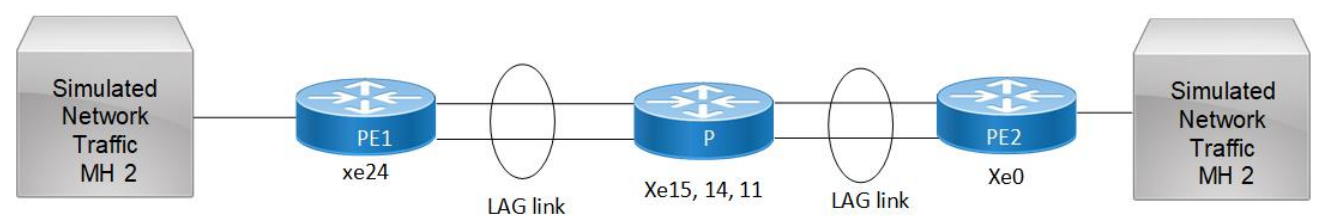
In the given network topology, each of the nodes is configured to operate using the ISIS or OSPF protocol. Additionally, the network is running an EVPN service, which facilitates the extension of Layer 2 Ethernet services across this network infrastructure.

The topology comprises the links connecting the P and PE nodes, configured as channel groups (LAG) that bundle multiple physical links for increased bandwidth and redundancy. However, the current setup has a limitation: different services may utilize the same MPLS transport, potentially resulting in the same hashing value. Consequently, the network fails to optimize the available resources fully, leading to suboptimal performance and underutilization of the aggregated bandwidth provided by the channel group.

The Entropy label feature addresses this issue by introducing distinct entropy labels for different services within the MPLS label stack. This optimization results in better utilization of the available links in the LAG or ECMP. With this feature, the network evenly distributes traffic across the various physical links within the channel group. Instead of relying on a single link, the network simultaneously utilizes multiple links to handle bidirectional traffic between the P and PE nodes.

Implementation of the Entropy label feature enhances the routing and load balancing of network traffic. Consequently, the network can fully leverage the capabilities of the channel group setup, making the most of the aggregated bandwidth and improving overall network responsiveness.

Figure 1-1: Entropy Label



ISIS Configuration

P

The following are the step-by-step configurations on the P router.

<code>P(config-if)# router ISIS 1</code>	Enters IS-IS router configuration mode for the IS-IS process ID 1
<code>P(config-router)# metric-style wide</code>	Configures the IS-IS metric style as wide.
<code>P(config-router)# mpls traffic-eng router-id 48.48.48.48</code>	Sets the MPLS Traffic Engineering router ID to 48.48.48.48.
<code>P(config-router)# mpls traffic-eng level-1</code>	Enables MPLS Traffic Engineering for IS-IS Level 1
<code>P(config-router)# mpls traffic-eng level-2</code>	Enables MPLS Traffic Engineering for IS-IS Level 2.
<code>P(config-router)# capability cspf</code>	Enables the Constraint-Based Shortest Path First (CSPF) capability.
<code>P(config-router)# dynamic-hostname</code>	Allows dynamic hostname assignment.
<code>P(config-router)# bfd all-interfaces</code>	Enables Bidirectional Forwarding Detection (BFD) on all interfaces.

P(config-router)# net 49.0000.0000.0048.00	Sets the IS-IS network entity title (NET) for the router.
P(config-router)# passive-interface lo	Sets the loopback interface as a passive interface for IS-IS.
P(config-router)# segment-routing entropy-label	Enables the capability for Segment Routing with entropy labels.
P(config-router)# segment-routing mpls	Enables MPLS-based Segment Routing.
P(config-router)#line console 0	Enters console line configuration mode.
P(config-line)# exec-timeout 0 0	Configures the console timeout settings.
P(config-line)#exit	Exits the configuration mode of a specific line.

PE1

The following are the step-by-step configurations on the PE1 router.

PE1(config-router)#router isis 1	Enters the configuration mode for ISIS routing with process ID 1.
PE1(config-router)# is-type level-1-2	Configures the ISIS routing process as a level-1-2 router, supporting both Level 1 and Level 2 routing.
PE1(config-router)# metric-style wide	Configures the metric style for ISIS as wide.
PE1(config-router)# mpls traffic-eng router-id 45.45.45.45	Sets the MPLS Traffic Engineering (MPLS TE) router ID to 45.45.45.45.
PE1(config-router)# mpls traffic-eng level-1	Enables MPLS TE for Level 1 ISIS.
PE1(config-router)# mpls traffic-eng level-2	Enables MPLS TE for Level 2 ISIS.
PE1(config-router)# capability cspf	Enables the CSPF calculation capability.
PE1(config-router)# dynamic-hostname	Enables dynamic hostname generation for ISIS.
PE1(config-router)# bfd all-interfaces	Enables BFD on all interfaces.
PE1(config-router)# net 49.0000.0000.0045.00	Sets the NET for ISIS.
PE1(config-router)# passive-interface lo	Configures the loopback interface as a passive interface in ISIS.
PE1(config-router)# segment-routing entropy-label	Enables segment routing with entropy label support.
PE1(config-router)# segment-routing mpls	Enables MPLS segment routing.
PE1(config-router)#Exit	Exits the ISIS router configuration mode.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2(config-router)#router isis 1	Enters the configuration mode for ISIS routing with instance 1.
PE2(config-router)# is-type level-1-2	Sets the ISIS level to level-1-2.
PE2(config-router)# metric-style wide	Configures the metric-style as wide for ISIS.
PE2(config-router)# mpls traffic-eng router-id 22.22.22.22	Sets the MPLS traffic engineering router ID to 22.22.22.22.
PE2(config-router)# mpls traffic-eng level-1	Enables MPLS traffic engineering for ISIS level 1.
PE2(config-router)# mpls traffic-eng level-2	Enables MPLS traffic engineering for ISIS level 2.
PE2(config-router)# capability cspf	Enables the CSPF capability.
PE2(config-router)# dynamic-hostname	Enables dynamic hostname updates for ISIS.
PE2(config-router)# bfd all-interfaces	Enables BFD on all interfaces for faster link failure detection.
PE2(config-router)# net 49.0000.0000.0022.00	Sets the NET for ISIS.
PE2(config-router)# passive-interface lo	Configures the loopback interface as a passive interface for ISIS.
PE2(config-router)# segment-routing entropy-label	Enables the segment routing capability for entropy labels.
PE2(config-router)# segment-routing mpls	Enables MPLS segment routing.
PE2(config-router)#Exit	Exits the ISIS router configuration mode.

OSPF Configuration

P

The following are the step-by-step configurations on the P router.

P(config-if)# router ospf 1	Enters OSPF router configuration mode for the OSPF process ID 1
P(config-router)# segment-routing entropy-label	Enables the capability for Segment Routing with entropy labels.
P(config-router)# segment-routing mpls	Enables MPLS-based Segment Routing.

PE1

PE1(config-router)#router ospf 1	Enters the configuration mode for OSPF routing with process ID 1.
PE1(config-router)# segment-routing	Enables MPLS segment routing.

mpls	
PE1(config-router)# segment-routing entropy-label	Enables segment routing with entropy label support.

PE2

The following are the step-by-step configurations on the PE2 router.

PE2(config-router)#router ospf 1	Enters the configuration mode for OSPF routing with instance 1.
PE2(config-router)# segment-routing entropy-label	Enables the segment routing capability for entropy labels.
PE2(config-router)# segment-routing mpls	Enables MPLS segment routing.

Implementation Examples

Scenario: Achieve load balancing across Link Aggregation Group (LAG) in a network:

- Configure ISIS or OSPF with Segment Routing (SR) extensions in the network.
- Enable entropy feature under router isis or ospf.
- Use entropy labels to distribute traffic evenly across LAG, optimizing resource utilization.

New CLI Commands

Here is the compilation of new commands for configuring Entropy Label for Segment Routing.

- `segment-routing entropy-label` in the “New Features in Release 6.4.1” document.

segment-routing entropy-label

Use this command to enable and configure entropy labels within the Segment Routing framework in ISIS instances. Use `no` form of CLI to disable the entropy labels within the Segment Routing framework.

Command Syntax

```
segment-routing entropy-label
no segment-routing entropy-label
```

Parameters

enable

Enable Segment Routing entropy label in ISIS or OSPF instance

Disable

Disable Segment Routing entropy label in ISIS or OSPF instance

Command Mode

Router ISIS or OSPF

Applicability

This command was introduced in [[Undefined variable Global-variable.OcNOS- version 6.4.0]].

Example

```
(config-router)#segment-routing entropy-label
```

Validation

ISIS Validation

Validation on ISIS

```
R1#show isis segment-routing capabilityTag 1 Segment-Routing:
Advertisement Router Capability :1.1.1.1
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :16000 - 23999
Total SID'S Supported (SRLB)   :0
SRLB Range List Count          :0
Advertisement Router Capability :3.3.3.3
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :16000 - 23999
Total SID'S Supported (SRLB)   :0
SRLB Range List Count          :0
Advertisement Router Capability :5.5.5.5
Algorithm0                     :0
SRMS Preference                :0
Total SID'S Supported          :3001
SR ERLD                        :6
SID Range List Count           :1
SID's Range                    :16000 - 23999
Total SID'S Supported (SRLB)   :0
SRLB Range List Count          :0
R1#
R1#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
i>    3.3.3.3/32  1    1      0      Yes  16003    xe3      Yes  1.3.0.3  00:10:05
i>    5.5.5.5/32  2    2      0      Yes  16005    xe3      Yes  1.3.0.3  00:10:05
```

OSPF Validation

Validation on OSPF

```
R1#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
O>    3.3.3.3/32  1  19      0      Yes  16003      xe3      Yes  1.3.0.3  00:02:33
O>    5.5.5.5/32  2  21      0      Yes  16005      xe3      Yes  1.3.0.3  00:02:33
R1#           pol      Yes  20.1.1.15
```

Abbreviations

The following are some key abbreviations and their meanings relevant to this document:

Adj-SID	Adjacency Segment Identifier
ECMP	Equal-Cost Multipath
EL	Entropy Label
ELI	Entropy Label Indicator
ELC	Entropy Label Capability
ERLD	Entropy Readable Label Depth
FEC	Forwarding Equivalence Class
ISIS	Intermediate System to Intermediate System
LAG	Link Aggregation Group
LSP	Label Switched Path
LSR	Label Switching Router
MPLS	Multiprotocol Label Switching
MSD	Maximum SID Depth
Node SID	Node Segment Identifier
OAM	Operations, Administration, and Maintenance
RLD	Readable Label Depth
SID	Segment Identifier
SPT	Shortest Path Tree
SR	Segment Routing
SRGB	Segment Routing Global Block
VPN	Virtual Private Network

Glossary

Entropy Label	An additional label in the MPLS (Multiprotocol Label Switching) header used to enhance load balancing and path distribution in networks.
Load Balancing	The practice of distributing network traffic across multiple paths or resources to prevent congestion and optimize network performance.
Path Distribution	The process of selecting and directing traffic along various network paths, often to ensure efficient utilization and redundancy.
Network Efficiency	The measure of how effectively a network utilizes its resources to deliver data, minimizing waste and maximizing performance.
Multiprotocol Label Switching (MPLS)	A protocol used in telecommunications networks to efficiently direct data packets using labels, enhancing speed and performance.
Label Switching	A mechanism for forwarding data packets based on labels, typically used in MPLS networks for efficient routing.
Hashing Mechanism	A method for computing hash values, often used in load balancing to evenly distribute traffic across network resources.
Hardware-Dependent	Referring to features or functionality that rely on specific hardware components or capabilities.
Segment Routing	A networking technology that allows for the efficient routing of data packets by specifying the exact path they must follow.

Seamless BFD On Qumran2

Overview

Seamless Bidirectional Forwarding Detection (S-BFD) is an extension or enhancement of Bidirectional Forwarding Detection (BFD). This protocol is primarily used in IP-based networks to monitor and detect faults quickly between systems. S-BFD is designed to provide a seamless and rapid fault detection mechanism while minimizing the impact on network resources. It is a simplified mechanism for using BFD with a large proportion of negotiation aspects eliminated. BFD provides a smooth and continuous operational experience for applications in a network.

Feature Characteristics

S-BFD consists of an initiator (a network node hosts an S-BFD Initiator) and a responder (a network node hosts an S-BFD Reflector). In network traffic, S-BFD detects a link failure, and the traffic immediately switches to a backup path. The traffic returns to the primary once the link is up or the corresponding path becomes active.

S-BFD works on the following concepts:

- Initiator: A network node hosting an S-BFD Initiator.
- Responder: A network node hosting an S-BFD Reflector.
- S-BFD Initiator: In a network, an S-BFD session performs a continuity test by sending S-BFD packets to a remote entity.
- BFD Discriminator: A BFD Discriminator is allocated for an SBFD Initiator.
- SBFD Reflector: In a network node, S-BFD session gathers incoming S-BFD control packets from local entities and generates responses to S-BFD control packets.

For more information, see the [Seamless BFD for SR-TE \(page 622\)](#) in the OcNOS Segment Routing Config document.

Benefits

The following are the benefits of using S-BFD on Q2:

- Quick provisioning: S-BFD can be deployed in any network with less time and effort, ensuring the configured environment is rapid and efficient.
- Improved control: S-BFD continuously monitors the network, predicts the network blocks, and diverts the network traffic to back up path.
- Flexibility for network nodes: S-BFD easily adapts to network functionalities, ensuring efficient traffic distribution and minimizing congestion.
- Initiating path monitoring: Path monitoring in a network involves regular monitoring and checking the communication path between two network endpoints.

S-BFD provides quick convergence time is 50 milliseconds.

Prerequisites

The following prerequisites are mandatory before installing S-BFD:

- Configure ISIS.
- Configure Segment Routing policy.

Configuration

S-BFD is supported only on Qumran2 platforms. The topology below describes active routers PE1,P3,P4, PE2 and as a backup PE1,P2, PE2 with lowest preference.

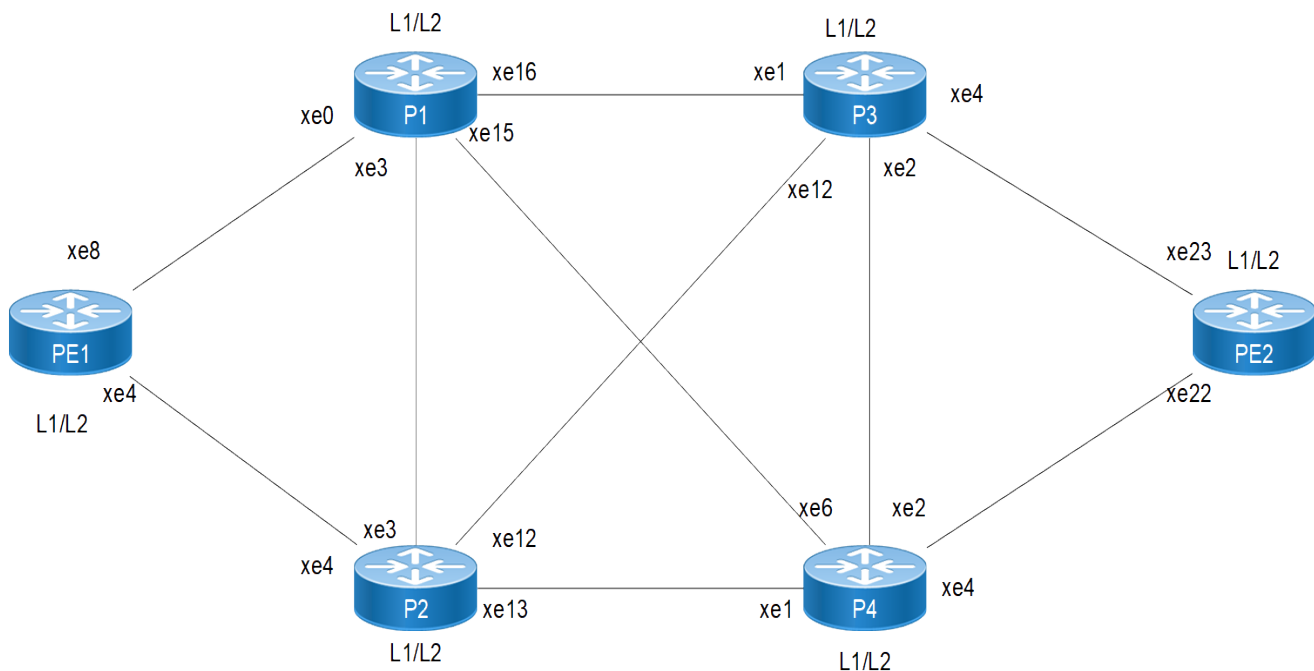
For more information on the S-BFD configurations, see the *Seamless BFD for SR-TE Configuration (page 623)* in the OcNOS Segment Routing Config document.

Topology

In a network, a node can be either the initiator or the reflector, the initiator sends an S-BFD packet for the detection to the reflector. The reflector reflects the received S-BFD packet. As soon as the S-BFD packet is received from the initiator, it checks that the S-BFD discriminator in the packet is the same. If it doesn't match the packet is discarded. If it matches, the reflector reflects the packet.

The following topology illustrates the S-BFD process.

Figure 1-1: S-BFD on Qumran2



For this topology to work, ensure that these following conditions are met



Notes:

- Ensure that prefix SIDs are unique globally.
- Use L1 or L2 routers throughout your SR domain.

Validation

```

PE2-7048#show bfd session

BFD process for VRF: (DEFAULT VRF)
=====
Sess-Idx  Remote-Disc  Lower-Layer  Sess-Type  Sess-State  UP-Time  Interface  Down-
Reason  Remote-Addr
1281      45.45.45.45  MPLS LSP      Single-
Hop Up      00:01:15  pol.10      NA          45.45.45.45/32

Number of Sessions:      1

PE2-7048#show segment-routing policy detail

Policy-Name: 1      Color 1      End-point 45.45.45.45      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:01:13
State Transition Count: 1
CSPF Retry Limit: 100      CSPF Retry Interval: 10
S-BFD is enabled.
Binding SID :
BSID: 25600
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 300      Path Type: Explicit      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :16042
Segment1[LABEL]: Label :16045
Out-if: pol.10      Out-label-stack: 3/16045
Backup ftn_ix: 6      (calculated based on s-bfd)
Attributes:
Configured:
Explicit segment-list Name: 48-42
Last Recorded Error: Next-hop resolution failed for SID-LIST, 00:02:15 ago

CP ID: 2, S-BFD backup
Preference: 100      Path Type: Explicit      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :16043
Segment1[LABEL]: Label :16045
Out-if: xe0      Out-label-stack: 3/16045
Attributes:
Configured:
Explicit segment-list Name: 48-43
Last Recorded Error: Next-hop resolution failed for SID-LIST, 00:02:15 ago

```

For more information, see the *Seamless BFD for SR-TE Validation* ([page 632](#)) in the OcNOS Segment Routing Config document.

Implementation Examples

To achieve minimal traffic convergence time and a quick switch over to backup if there is any link failure in the primary path.

- a. Configure the S-BFD Segment Routing policy NAME where the data enters the traffic on a network and decides which path to flow.

- b. Configure the S-BFD discriminator A.B.C.D at the outgoing or existing data from the network traffic.
- c. S-BFD starts monitoring the segment routing policy path, once it is mapped to S-BFD.

Troubleshooting

- d. Check if the discriminator is learnt at initiator.
- e. Check if the learnt discriminator is the same as the segment routing policy end-point address.
- f. Check if the segment routing policy is mapped to S-BFD is operationally up.

Abbreviations

Acronym	Description
S-BFD	Seamless Bidirectional Forwarding Detection
SR	Segment Routing
SID	Segment Identifiers
ISIS	Intermediate System to Intermediate System
Q2	Qumran

Glossary

The following provides definitions for key terms used throughout this document.

ISIS	ISIS protocol provides the solution for connecting and managing virtual networks within a data center or network infrastructure
SR	Segment Routing is a method where the sender of a packet can partially or completely specify a route in a network through which a packet is sent
SID	A segment routing mapping server allocates Segment Identifiers (SIDs) for prefixes and ranges in an ISIS segment routing domain
Ingress	Flow of data traffic into a network
Egress	Outgoing or exiting data traffic from a network

Segment Routing Configuration

Source routing is a technique where the sender of a packet can partially or completely specify a route in a network through which a packet is sent. Segment routing is a form of source routing where nodes and links are represented as segments. The path that a particular packet needs to traverse is represented by one or more segments. The list of segments is inserted into the packet itself and each segment in the path represents a particular node or an adjacency through which the packet needs to pass. The OcNOS implementation of segment routing is based on draft-ietf-spring-segment-routing-09.

A segment can be any instruction, topological or service based.

A segment can be

- Local to an SR node or global within an SR domain.
- IGP-based forwarding construct
- BGP-based forwarding construct

A segment may be associated with topological instructions.

For example:

- A topological local segment may instruct the node to forward the packet via specific outgoing interface.
- A topological global segment may instruct the SR domain to forward the packet via specific path to destination.

A segment may be associated with a service instruction.

- Packet should be processed by a container or Virtual Machine (VM) associated with the segment

They are importantly two kinds of segments.

- Prefix Segment

It is used to forward the packet along the shortest path to reach the prefix. When the prefix is that of the loopback interface which identifies the node and it's called a Node Segment. Prefix Segments are global segments and all the nodes in SR domain has the forwarding entry available for the prefix segment advertised.

- Adjacency Segment

It is used to forward the packet via a specific link to a particular neighbor. It's generally a local segment and only the node which holds the adjacency has the forwarding entry available for that adjacency.

OcNOS uses prefix segments which forward a packet along the shortest path to reach the prefix. Prefix segments are global and all the nodes in the segment routing domain advertise the forwarding entry for the prefix segment. When a prefix is for a loopback interface that identifies a node, it is called a node segment.

Segment routing does not require any additional control plane protocol and is implemented by extending an existing interior gateway protocol (IGP) such as OSPF and ISIS. Segment routing replaces MPLS control plane protocols such as LDP or RSVP.

In OcNOS, MPLS clients such as LDP and RSVP create FEC-to-NHLFE and Incoming Label Map (FTN/ILM) entries by signaling within the MPLS domain. After this, the entries are installed into the MPLS RIB hosted by NSM.

The segment routing framework reuses the existing MPLS framework with OSPF and ISIS which acts as an MPLS client. OSPF and ISIS with segment routing extensions exchanges the segment information within the segment routing domain. These segments are converted to MPLS FTN/ILM entries using a library. After this, the entries are installed into the same MPLS RIB hosted by NSM.

OcNOS supports ISIS and OSPF extensions to achieve segment routing via the MPLS data plane. OcNOS supports prefix segments and adjacency segments.

In segment routing, the path states are maintained only at the ingress node and the path to follow is pushed into the packet itself. The transit and egress nodes do not maintain state for each path traversing through them. The configuration overhead is less than traditional MPLS.

The major benefits of segment routing are as follows.

1. Simplified
 - a. When applied to the MPLS data plane, Segment Routing offers the ability to tunnel MPLS services (VPN, VPLS, and VPWS) from an ingress provider edge to an egress provider edge without any other protocol than an IGP (ISIS or OSPF).
 - b. Simpler operation without separate protocols for label distribution (for example, no LDP or RSVP).
 - c. No complex LDP or IGP synchronization to troubleshoot.
2. Ready for SDN
 - a. Segment Routing is a compelling architecture that supports Software-Defined Network (SDN) and is the foundation for Application Engineered Routing (AER).
 - b. It strikes a balance between network-based distributed intelligence, such as automatic link and node protection, and controller-based centralized intelligence, such as traffic optimization.
3. Scalable
 - a. Avoid thousands of labels in LDP database.
 - b. Avoid thousands of MPLS Traffic Engineering LSPs in the network.
 - c. Avoid thousands of tunnels to configure.
4. Supports Fast Reroute (FRR)
 - a. The traditional LFA and RLFA technologies have topology constraints that mean they are unable to implement 100% fault protection.
 - b. Segment routing provides Topology Independent Loop Free Alternate (TI-LFA) as its main solution for FRR.
 - c. In case of link or node failures in a network, MPLS uses the FRR mechanism for convergence.

Segment Routing Global Block

The Segment Routing Global Block (SRGB) is a local property of a segment routing node. In the context of MPLS, it is a set of “local labels” for global segments.

By default, OcNOS uses the same local label range (16000-23999) for all the segment routing nodes for SRGB.

If a node participates in multiple SR domains, there is one SRGB for each SR domain. In SR-MPLS, SRGB is a local property of a node and identifies the set of local labels reserved for global segments.

In SR-MPLS, using identical SRGBs on all nodes within the SR domain is strongly recommended. Doing so eases operations and troubleshooting as the same label represents the same global segment at each node.

When SRGB is not configured, the system reserves a default label range.

The SRGB default value is 16000 to 23999. The SRGB can be configured as follows:



Note: Make sure that the labels in the SRGB label range are not used by any other protocols (LDP, RSVP, BGP, static LSP, ISIS-SR policy, OSPF-SR policy). To check the label ranges configured for each of the protocols use `show mpls label-space 0` and re-configure the SRGB label range with a label range that is available.

SRGB in Global Mode

```
#conf t
(config)#segment-routing
(config-sr)#global block 30000 50000
```

SRGB declared in global mode can be used by either ISIS or OSPF if they do not have configured SRGB in their respective routing process level.

SRGB under ISIS

```
(config)#router isis isis1
(config-router)#isis segment-routing global block <16-1048575>
```

SRGB under OSPF

```
(config)#router ospf 1
(config-router)#ospf segment-routing global block <16-1048575>
```

Segment Identifiers

Segments are identified by a Segment Identifier (SID) which is an unsigned 32-bit integer. Because the MPLS data plane is used, the segments are identified by a 20-bit integer, leaving the 12 left-most bits of the SID unused. A SID has an absolute value and index (label) allocated for the segment. Because the SRGB is the same across the entire domain, all nodes identify the segment with the same absolute value.

Prefix SID Absolute Value

Specify an absolute SID-value for each node to create a specific prefix SID within the configured SRGB range.

When a Prefix-SID is configured as absolute, the same value is used for packet-switching.

```
(config-if)#prefix-sid absolute <16-1048575>
```

Prefix SID Index Value

Specify an index SID-index for each node to create a prefix SID based on the lower boundary of the SRGB and the index.

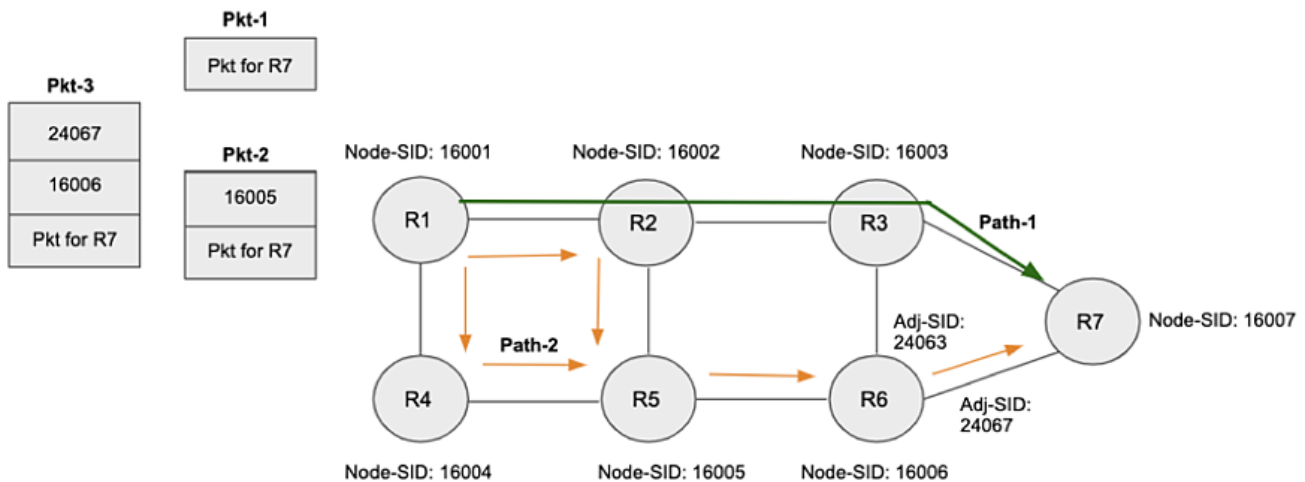
```
(config-if)#prefix-sid index <0-1048575>
```

This index value will be used for calculating absolute MPLS label by adding base value of SRGB. In case of default SRGB (16000-23999) if index value is 1000, the MPLS label value will $(16000 + 1000) = 17000$.

Forwarding Example with SIDs

Topology shows an example of forwarding a packet using a prefix SID.

Figure 46. Forwarding example



1. If ingress node R1 receives packet destined for R7 with no SR label stack in packet header, the packet will get forwarded to R7 along the IGP shortest-path (R1-R2-R3-R7).
2. If the packet was received with SR label stack of [16005], R1 inspects the top label which is 16005. 16005 is the node SID associated with R5 and so this tells R1 to forward the packet along IGP shortest-path to R5 (R1-R2-R5 or R1-R4-R5). The next hop node (R2 or R4) does the same action as R1. On receiving the packet, R5 inspects the top label which is 16005 and since it matches its node SID, it pops the top label. There are no more labels in the stack and R5 forwards the packet to R7 along the IGP shortest-path (R5-R6-R7).
3. If the packet was received with SR label stack of [16006, 24067], R1 inspects the top label which is 16006 and because that is the node SID associated with R6, R1 forwards the packet along the IGP shortest-path to R6 (R1-R2-R3-R6, R1-R2-R5-R6 or R1-R4-R5-R6). R6 inspects the top label which is 16006 and because it matches its node SID, R6 pops the top label and inspects the next label which is 24067. 24067 is the adjacency SID associated with R6's adjacency with R7 so this tells R6 to pop the label and forward the packet over its link connected to R7.

Segment Routing ECMP for ISIS or OSPF

Overview

Segment Routing (SR) is a source-based routing technique where you can specify a route in a network through which a packet is sent. The path that a particular packet needs to traverse is represented by one or more segments (nodes and links).

Equal Cost Multipath (ECMP) refers to single-hop, equal-cost links between adjacent nodes with a forwarding mechanism for routing traffic along multiple paths of equal cost. For ECMP enabled devices, OcNOS uses Forwarding Plane Load Balancing and installs the maximum number of ECMP routes supported by the kernel. This allows for load balancing to be performed with more than one next-hop to reach a destination.

SR with ECMP support for Intermediate System to Intermediate System (ISIS) and Open Shortest Path First (OSPF), selects all the valid equal-cost next-hop peers of an IP prefix and creates ECMP Incoming Label Maps (ILM) and FEC-to-NHLFE (FTN) entries for that prefix with all the IS-IS/OSPF SR next-hops in the forwarding plane.

Feature Characteristics

The main characteristics of SR ECMP are as follows:

- Distributes packets across multiple logical paths (LSP) carrying qualified traffic over MPLS underlay using SR as a transport. The traffic is distributed based on a collection of such LSPs, known as an ECMP set.
- Uses an internal hashing algorithm by the forwarding plane to distribute traffic among multiple next-hops, assigning the traffic flow to a particular next-hop.
- When TI-LFA is enabled, IGP adds the ECMP next-hops as primary and computes and adds a backup for each of the ECMP next-hops in the FTN and ILM entry of the prefix.
- When TI-LFA is disabled, IGP computes and adds all the ECMP next-hops in the FTN and ILM entry of the prefix.



Note: Load balancing on ECMP next-hops does not guarantee equal distribution of traffic across the ECMP paths. Load balancing in the hardware is done using hashing of a combination of headers in the traffic streams, such as src, dst mac, ip pair and so on. The unique combination of such headers may result in the same hash which in turn results in the same ECMP next-hop. This causes unequal distribution of traffic within the ECMP next-hop interfaces.

Benefits

The key benefits of SR ECMP are as follows:

- Distributes traffic across multiple equal-cost paths, effectively balancing the load, optimizing resource utilization throughout the network, and preventing congestion.
- Reroutes traffic to alternative equal-cost paths in case of a link or node failure, thus reducing downtime and maintaining continuous service.
- Offers redundancy by utilizing multiple paths such that if one path becomes unavailable, traffic is redirected to other paths seamlessly, bolstering network resilience and reliability, when TI-LFA is enabled.

Prerequisites

The SR ECMP feature can be enabled on the following devices:

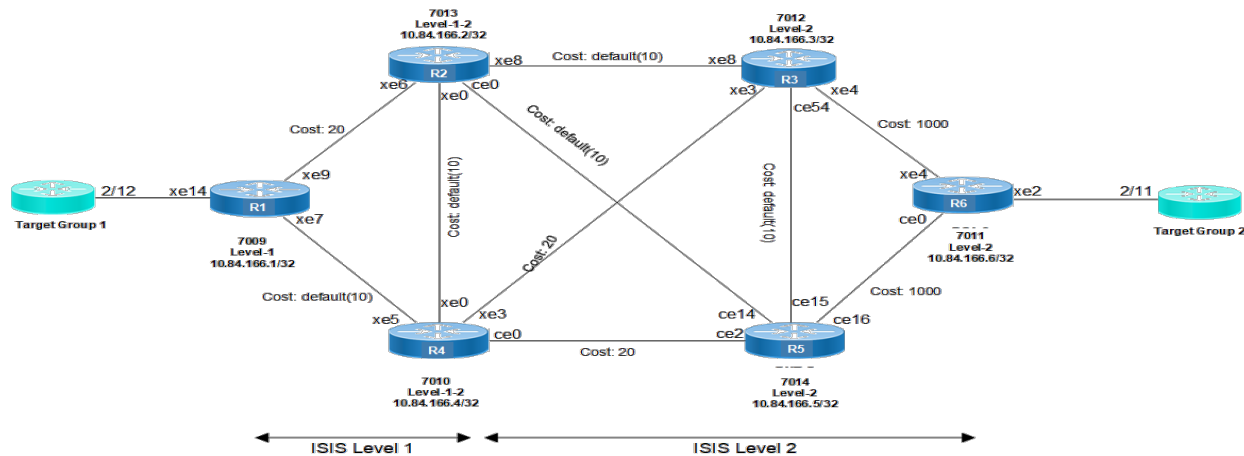
- OcNOS devices that support ISIS/OSPF Segment Routing.
- OcNOS devices that support MPLS services such as VPLS, VPWS, L3VPN, 6PE, 6VPE and EVPN (ELINE, ELAN, ETREE).

ECMP with ISIS-SR Configuration

The following configuration enables ECMP with ISIS-SR for L3VPN and EVPN ELINE services.

Topology

This topology includes Edge nodes - R1 and R2, Intermediate nodes - R2, R3, R4, and R5 and Target Groups 1 and 2.



The ECMP Label Switched Path (LSP) derived from the above topology is as follows:

Source	Destination	ECMP	Path	Cost
R1	R2	YES	R1-R2	30
			R1-R4-R2	30
R1	R6	YES	R1-R2-R3-R6	1040
			R1-R4-R5-R6	1040

To configure SR ECMP functionality on PE nodes with ISIS as IGP, follow the steps mentioned below:

1. Configure loop-back interface.
 - a. Access interface configuration mode for the loopback interface (`interface lo`).
 - b. Assign an IPv4 address to the loopback interface using the IPv4 address command followed by the desired IPv4 address and subnet mask (`ipv4 address 10.84.166.1/32`).
 - c. Assign appropriate prefix-sid index for the loopback interface (`prefix-sid index 100 no-php`).
 - d. Configure IS-IS for IPv4 on the loopback interface using the `ip router isis` command, specifying the IS-IS process ID (`ip router isis 1`).


```
R1(config)#interface lo
R1(config-if)# ip address 127.0.0.1/8
R1(config-if)# ip address 10.84.166.1/32 secondary
R1(config-if)# ipv6 address ::1/128
R1(config-if)# prefix-sid index 100 no-php
R1(config-if)# ip router isis 1
R1(config-if)# exit
```

2. Configure network interface.

- e. Access interface configuration mode for the desired network interface (interface xe9 and xe7).
- f. Assign an IPv4 address to the loopback interface using the ipv4 address command followed by the desired IPv4 address and subnet mask (ip address 10.11.22.1/30).
- g. Configure the MTU for the interface (mtu 9216).
- h. Configure IS-IS for IPv4 on the interface using the IP router ISIS command, specifying the IS-IS process ID (ip router isis 1).

```
R1(config)#interface xe9
R1(config-if)# load-interval 30
R1(config-if)# ip address 10.11.22.1/30
R1(config-if)# mtu 9216
R1(config-if)# label-switching
R1(config-if)# ip router isis 1
R1(config-if)#
R1(config-if)#exit
```

3. In global configuration mode, perform the following as shown in the configuration snapshots below:

- i. Configure ISIS Settings
- j. Perform the BGP Configuration
- k. Create IP VRF:
- l. Define the L3VPN access intf configuration and IP VRF mapping.
- m. Create MAC VRF.
- n. Define the ELINE instance and with the MAC VRF Mapping and access intf configuration
- o. Enable ECMP for SR entities for FTN as its PE Edge node using the command `mpls ftn-ecmp sr`



Note: Use ECMP SR for ILM in case of P transit nodes.

Configuration Snapshot

Snapshot of Edge Nodes (R1 and R6)

```
R1#sh run
!
! Software version: UFI_S9510-30XC-OcNOS-SP-PLUS-6.6.0.99-Alpha
10/
!
! Last configuration change at 00:10:29 UTC Thu Nov 16 2023 by root
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
```

```
!  
logging console 5  
logging level all 5  
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  
!  
mpls ilm-ecmp sr  
mpls ftn-ecmp sr  
!  
hostname R1  
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  
!  
evpn mpls enable  
!  
evpn mpls irb  
!  
ip vrf management  
!  
ip vrf vrf701  
  rd 10:701  
  route-target both 10:701  
!  
mac vrf ELINE_R1_R6_501  
  rd 10.84.166.1:501  
  route-target both 501:501  
!  
evpn mpls vtep-ip-global 10.84.166.1  
!  
evpn mpls id 501 xconnect target-mpls-id 1501  
  host-reachability-protocol evpn-bgp ELINE_R1_R6_501  
!  
router ldp  
  targeted-peer ipv4 10.84.166.6  
  exit-targeted-peer-mode  
!  
interface ce0  
!  
interface ce1  
!  
interface eth0  
  ip vrf forwarding management  
  ip address dhcp  
!  
interface lo  
  ip address 127.0.0.1/8  
  ip address 10.84.166.1/32 secondary  
  ipv6 address ::1/128  
  prefix-sid index 100 no-php  
  ip router isis 1  
!  
interface lo.management
```

```
ip vrf forwarding management
ip address 127.0.0.1/8
ipv6 address ::1/128
!
interface xe2
!
interface xe3
!
interface xe4
!
interface xe5
!
interface xe6
!
interface xe7
speed 10g
load-interval 30
ip address 10.11.44.1/30
mtu 9216
label-switching
ip ospf network point-to-point
ip router isis 1
!
interface xe8
!
interface xe9
load-interval 30
ip address 10.11.22.1/30
mtu 9216
label-switching
ip router isis 1
isis wide-metric 20
!
interface xe10
!
interface xe11
!
interface xe12
!
interface xe13
!
interface xe14
mtu 9216
!
interface xe14.501 switchport
description ELINE_R1_R6_501
encapsulation dot1q 501
load-interval 30
mtu 9216
access-if-evpn
map vpn-id 501
!
interface xe14.701
encapsulation dot1q 701
load-interval 30
ip vrf forwarding vrf701
ip address 100.7.1.1/24
mtu 9216
!
interface xe15
!
interface xe16
!
interface xe17
!
interface xe18
!
interface xe19
```

```
!  
interface xe20  
!  
interface xe21  
!  
interface xe22  
!  
interface xe23  
!  
interface xe24  
!  
interface xe25  
!  
interface xe26  
!  
interface xe27  
!  
interface xe28  
!  
interface xe29  
!  
exit  
!  
router isis 1  
  is-type level-1  
  metric-style wide  
  mpls traffic-eng router-id 10.84.166.1  
  mpls traffic-eng level-1  
  capability cspf  
  bfd all-interfaces  
  net 49.0001.0000.0001.0011.00  
  isis segment-routing global block 20000 23000  
  segment-routing mpls  
!  
router bgp 65010  
  bgp router-id 10.84.166.1  
  neighbor 10.84.166.6 remote-as 65010  
  neighbor 10.84.166.6 update-source lo  
  !  
  address-family vpnv4 unicast  
  neighbor 10.84.166.6 activate  
  exit-address-family  
  !  
  address-family l2vpn evpn  
  neighbor 10.84.166.6 activate  
  exit-address-family  
  !  
  address-family ipv4 vrf vrf701  
  redistribute connected  
  neighbor 100.7.1.2 remote-as 101  
  neighbor 100.7.1.2 activate  
  exit-address-family  
  !  
exit  
!  
!  
end  
  
R1#  
R1#
```

Snapshot of Transit Nodes (R2, R3, R4, and R5)

```
R2#  
R2#sh run  
!  
! Software version: EC_AS5916-54X-OcNOS-SP-MPLS-6.5.3.86-Alpha
```

```
10/1 3/2024 14:39:27
!
! Last configuration change at 13:12:58 UTC Mon Oct 14 2024 by
ocno s
!
feature netconf-ssh vrf management
feature netconf-tls vrf management
no feature netconf-ssh
no feature netconf-tls
service password-encryption
!
logging console 5
logging level all 5
snmp-server enable traps link linkDown
snmp-server enable traps link linkUp
!
hardware-profile statistics ingress-acl enable
!
qos enable
!
mpls ilm-ecmp sr
!
hostname R2
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
!
interface ce0
load-interval 30
ip address 10.22.55.1/30
mtu 9216
label-switching
ip ospf network point-to-point
ip router isis 1
!
interface ce1
!
interface ce2
!
interface ce3
!
interface ce4
!
interface ce5
!
interface eth0
ip vrf forwarding management
ip address 192.168.3.10/24
!
interface lo
ip address 127.0.0.1/8
ip address 10.84.166.2/32 secondary
ipv6 address ::1/128
prefix-sid index 200 no-php
ip router isis 1
```

```
!  
interface lo.management  
  ip vrf forwarding management  
  ip address 127.0.0.1/8  
  ipv6 address ::1/128  
!  
interface xe0  
  load-interval 30  
  ip address 10.22.44.1/30  
  mtu 9216  
  label-switching  
  ip ospf network point-to-point  
  ip router isis 1  
!  
interface xe1  
!  
interface xe2  
!  
interface xe3  
!  
interface xe4  
!  
interface xe5  
!  
interface xe6  
  load-interval 30  
  ip address 10.11.22.2/30  
  mtu 9216  
  label-switching  
  ip ospf network point-to-point  
  ip router isis 1  
  isis wide-metric 20  
!  
interface xe7  
!  
interface xe8  
  load-interval 30  
  ip address 10.22.33.1/30  
  mtu 9216  
  label-switching  
  ip ospf network point-to-point  
  ip router isis 1  
!  
interface xe9  
!  
interface xe10  
!  
interface xe11  
!  
interface xe12  
!  
interface xe13  
!  
interface xe14  
!  
interface xe15  
!  
interface xe16  
!  
interface xe17  
!  
interface xe18  
!  
interface xe19  
!  
interface xe20  
!  
interface xe21
```

```
!  
interface xe22  
!  
interface xe23  
!  
interface xe24  
!  
interface xe25  
!  
interface xe26  
!  
interface xe27  
!  
interface xe28  
!  
interface xe29  
!  
interface xe30  
!  
interface xe31  
!  
interface xe32  
!  
interface xe33  
!  
interface xe34  
!  
interface xe35  
!  
interface xe36  
!  
interface xe37  
!  
interface xe38  
!  
interface xe39  
!  
interface xe40  
!  
interface xe41  
!  
interface xe42  
!  
interface xe43  
!  
interface xe44  
!  
interface xe45  
!  
interface xe46  
!  
interface xe47  
!  
exit  
!  
router isis 1  
  is-type level-1-2  
  metric-style wide  
  mpls traffic-eng router-id 10.84.166.2  
  mpls traffic-eng level-1  
  mpls traffic-eng level-2  
  capability cspf  
  bfd all-interfaces  
  net 49.0001.0000.0001.0022.00  
  redistribute isis level-2 into level-1  
  isis segment-routing global block 20000 23000  
  segment-routing mpls  
!
```

```

ip route vrf management 0.0.0.0/0 192.168.3.1 eth0
!
!
end
R2#

```

Validation

Here are the show outputs that display the ISISv4 neighbour and routing information with ECMP for R1.

Validation of SR-ECMP on R1 [Edge Router]

```

R1#sh clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag 1: VRF : default
System Id      Interface  SNPA                State  Holdtime  Type Protocol
0000.0001.0044 xe7        b86a.97c8.3dcb      Up     19        L1    IS-IS
0000.0001.0022 xe9        80a2.352b.7008      Up     19        L1    IS-IS
R1#
R1#sh clns neighbors detail

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag 1: VRF : default
System Id      Interface  SNPA                State  Holdtime  Type Protocol
0000.0001.0044 xe7        b86a.97c8.3dcb      Up     21        L1    IS-IS
  L1 Adjacency ID: 1
  L2 Adjacency ID: 2
  Uptime: 00:04:27
  Area Address(es): 49.0001
  IP Address(es): 10.11.44.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
  Adjacency SID: 26880, ILM ID: 3

0000.0001.0022 xe9        80a2.352b.7008      Up     21        L1    IS-IS
  L1 Adjacency ID: 1
  L2 Adjacency ID: 2
  Uptime: 00:04:27
  Area Address(es): 49.0001
  IP Address(es): 10.11.22.2
  Level-1 Protocols Supported: IPv4
  Bidirectional Forwarding Detection is enabled
  Adjacency advertisement: Advertise
  Adjacency SID: 26881, ILM ID: 4

R1#

R1#sh ip route 10.84.166.6/32
VRF: Default, Routing entry for 10.84.166.6/32
  Known via "isis", distance 115, metric 1040, External Route Tag: 0, installed 00:22:23, best
  Last update 00:22:23 ago
  * 10.11.22.2, via xe9
  * 10.11.44.2, via xe7

```


R1#

The following show outputs displays the validation for L3VPN.

```

R1#sh ip bgp vpnv4 all neighbors
BGP neighbor is 10.84.166.6, remote AS 65010, local AS 65010, internal link, peer index: 4
  BGP version 4, local router ID 10.84.166.1, remote router ID 10.84.166.6
  BGP state = Established, up for 01:18:17
  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 VPNv4 Unicast: advertised and received
    Address family L2VPN EVPN: advertised and received
  Received 351 messages, 0 notifications, 0 in queue
  Sent 333 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: VPNv4 Unicast  BGP table version 9, neighbor version 9
  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 EVPN  BGP table version 6, neighbor version 6
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  Large Community attribute sent to this neighbor
  1 accepted prefixes
  Accepted AD:1 MACIP:0 MCAST:0 ESI:0 PREFIX:0
  1 announced prefixes

Connections established 3; dropped 2
Local host: 10.84.166.1, Local port: 179
Foreign host: 10.84.166.6, Foreign port: 40371
TCP MSS: (0), Advertise TCP MSS: (1460), Send TCP MSS: (1460), Receive TCP MSS: (536)
Sock FD : (29)
Nexthop: 10.84.166.1 lo
Nexthop global: :: lo
Nexthop local: :: lo
BGP connection: non shared networkLast Reset: 01:19:41, due to Hold Timer Expired (Notification sent)
Notification Error Message: (Hold Timer Expired/No sub-error code)

R1#sh 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>    200.7.1.0/24      1         2       51       Yes    25600       -
                10.84.166.6      00:05:18

R1#

```

The following show output displays the validation for EVPN ELINE.

```

R1#show bgp l2vpn evpn summary
BGP router identifier 10.84.166.1, 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						
10.84.166.6	4								
65010	353	336	6	0	0	01:19:10		1	1
0	0							0	0

Total number of neighbors 1

Total number of Established sessions 1

```
R1#sh 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			
501	----		1501	xe14.501	---	Single Homed Port ---
10.84.166.6		9216	AC-NW NW-SET			

Total number of entries are 1

```
R1#sh 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

Multipath		Underlay	Local	Remote		Local	Remote	MPLS-
Destination	Status	VPWS-ID	VPWS-ID	Policy		UC-Label	UC-Label	Grp-
Name	NHLFE-ix	NW-Intf	NW-Label					
10.84.166.6	Installed	501	1501	--		26240	26240	--
40	NA (e)		NA (e)					

Total number of entries are 1

R1#

```
R1#sh evpn mpls xconnect tunnel
```

EVPN-MPLS Network tunnel Entries

Source remote-evpn-id	Destination	Status	Up/Down	Update	local-evpn-id	
10.84.166.1	10.84.166.6	Installed	00:08:06	00:08:06	501	1501

Total number of entries are 1

R1#

The following show output displays the ECMP validation for ISIS-SR.

This command displays the ILM-ID, FTN-ID, In-Label & Out-Label for all the IS-IS routes which have ILM/FTN entry installed.

For the ECMP prefix 10.84.166.6//32, only one ILM/FTN entry will be installed, but Out-Label will be separate for each nexthop.2

```
R1#sh ip isis route prefix 10.84.166.6/32 detail
```

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 1: VRF : default

Hop	Destination	Metric	ILM-ID	FTN-ID	In-Label	Next-
	Interface	Tag				
ia	10.84.166.6/32	1040	9	5	20600	10.11.44.2
	0	20600				xe7
						10.11.22.2
	0	20600				xe9
	Src: 0000.0001.0022 Ifindex 10016					
	Src: 0000.0001.0044 Ifindex 10014					

R1#

This command displays In-Label and Out-Label of all next-hops of the FEC.

R1#sh isis segment-routing label detail

Tag 1 Segment-Routing: Label Table

FEC	In-Label	Out-Label	Out-Intf	Nexthop	Dependent
Tunnels					
10.84.166.4/32	20400	20400	xe7	10.11.44.2	
10.84.166.2/32	20200	20200	xe7	10.11.44.2	
		20200	xe9	10.11.22.2	
10.84.166.1/32	20100	N/A	lo	127.0.0.1	
10.84.166.3/32	20300	20300	xe7	10.11.44.2	
		20300	xe9	10.11.22.2	
10.11.44.2/32	26880	3	xe7	10.11.44.2	
10.84.166.5/32	20500	20500	xe7	10.11.44.2	
		20500	xe9	10.11.22.2	
10.84.166.6/32	20600	20600	xe7	10.11.44.2	
		20600	xe9	10.11.22.2	
10.11.22.2/32	26881	3	xe9	10.11.22.2	

R1#

Validate ECMP FTN, For the ECMP prefix 10.84.166.6/32, a single FTN entry is created with all the ECMP nexthops.

R1#show mpls forwarding-table 10.84.166.6/32

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>	10.84.166.6/32	5	40	-	(e)	-	-
	-	00:23:09					
	10.11.44.2	-	38	0	Yes	20600	xe7
			17	0	Yes	20600	xe9
	10.11.22.2	-					No

R1#

Validate ECMP FTN, For the ECMP prefix 10.84.166.6/32, a single FTN entry is created with all the ECMP nexthops.

For each nexthop, a cross-connect is created

R1#sh mpls ftn-table 10.84.166.6/32

Primary FTN entry with FEC: 10.84.166.6/32, id: 5, row status: Active, Tunnel-Policy: N/A,
 State: Installed
 CreateTime: 00:23:22, UpTime: 00:23:22, LastUpdate: N/A
 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: 8, in intf: - in label: 0 out-segment ix: 38 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 38, owner: ISIS-SR, Stale: NO, refcount: 6, out intf: xe7, out
label: 20600
    Nexthop addr: 10.11.44.2          cross connect ix: 8, op code: Push

    Cross connect ix: 8, in intf: - in label: 0 out-segment ix: 17 refcount: 1
    Owner: ISIS-SR, Persistent: No, Admin Status: Up, Oper Status: Up
    Out-segment with ix: 17, owner: ISIS-SR, Stale: NO, refcount: 5, out intf: xe9, out
label: 20600
    Nexthop addr: 10.11.22.2          cross connect ix: 8, op code: Push

  Dependent service info (count 1):
  [CONFIRM_VRF] ftn_ix 1 owner BGP prefix 200.7.1.0/24 nhlfe_ix 51 vrf 2

R1#

```



Note: This command displays the ILM-ID, FTN-ID, In-Label & Out-Label for all the IS-IS routes which have ILM/FTN entry installed. For the ECMP prefix 10.84.166.6//32, only one ILM entry will be installed, but Out-Label will be separate for each next-hop.

Validation of SR-ECMP on R2[Transit Router]

```

R1#sh ip isis route prefix 10.84.166.6/32 detail

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 1: VRF : default
      Destination      Metric      ILM-ID      FTN-ID      In-Label      Next-
Hop      Interface      Tag      Out-Label
ia 10.84.166.6/32      1040      9           5           20600         10.11.44.2     xe7
      0                20600
                                     10.11.22.2     xe9
      0                20600
Src: 0000.0001.0022 Ifindex 10016
Src: 0000.0001.0044 Ifindex 10014

R1#

```

For the ECMP prefix 10.84.166.6/32, a single ILM entry is created with all the ECMP next-hops.

```

R2#sh mpls ilm-table 10.84.166.6/32
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> 10.84.166.6/32      8           20600         20600         N/A          ce0          10.22
.55.2          Yes 00:25:39
           20600         20600         N/A          xe8          10.22
.33.2          Yes -
R2#

```

CLI Commands

The Segment Routing ECMP feature introduces the following configuration commands.

Below are the revised commands. For more details, refer to the [Segment Routing Commands \(page 956\)](#) chapter.

- [show ip isis route tilfa \(page 974\)](#)
- [show isis tilfa pq \(page 976\)](#)
- [show hsl mpls tunnel \(tunnel-id VALUE|\) \(page 973\)](#)
- [show ip ospf tilfa-backup-path \(page 980\)](#)
- [show ip ospf tilfa-repair-list \(page 981\)](#)

mpls ilm-ecmp sr

Use this command to enable programming of SR ILM entry as ECMP in hardware. This command applies only to data-plane and IGP ECMP calculation does not depend on this CLI. Only if this command is enabled, SR ILM entry will be installed as ECMP entry in hardware with all the ECMP next-hops.

Use `no` parameter of this command to disable programming of SR ILM entry as ECMP in hardware. When `no` parameter of this command is executed, the installed SR ECMP ILM entry will be changed to SR non-ECMP ILM entry.

Command Syntax

```
mpls ilm-ecmp sr
no mpls ilm-ecmp sr
```

Parameters

None

Default

Disabled

Command Mode

Configure mode

Applicability

Introduced the `mpls ilm-ecmp sr` parameter in the OcNOS version 6.5.3.

Example

The following sequence of commands is used to enable programming of SR ILM entry as ECMP in hardware.

```
#configure terminal
(config)#mpls ilm-ecmp sr
(config)#
```

mpls ftn-ecmp sr

Use this command to enable programming of SR FTN entry as ECMP in hardware. This command applies only to data-plane and IGP ECMP calculation doesn't depend on this CLI. Only if this command is enabled, SR FTN entry will be installed as ECMP entry in hardware with all the ECMP nexthops.

Use `no` parameter of this command to disable programming of SR FTN entry as ECMP in hardware. When `no` parameter of this command is executed, the installed SR ECMP FTN entry will be changed to SR non-ECMP ILM entry.

Command Syntax

```
mpls ftn-ecmp sr  
no mpls ftn-ecmp sr
```

Parameters

None

Default

Disabled

Command Mode

Configure mode

Applicability

Introduced the `mpls ftn-ecmp sr` parameter in the OcNOS version 6.5.3.

Example

The following sequence of commands is used to enable programming of SR FTN entry as ECMP in hardware.

```
#configure terminal  
(config)#mpls ftn-ecmp sr  
(config)#
```

show ip isis route prefix A.B.C.D/M

Use this command to display the ISIS routing table of the specified IPv4 prefix.

Command Syntax

```
show ip isis (WORD|) route ((prefix A.B.C.D/M)|)
```

Parameters

WORD

Information for a single ISIS area.

Prefix

Prefix.

A.B.C.D/M

IPv4 prefix.

Command Mode

Privileged exec mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Example

The following example displays the ISIS routing table of the specified IPv4 prefix.

```
#show ip isis route prefix 10.10.10.10/32

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 100: VRF : default
  Destination      Metric      Next-Hop      Interface      Tag
L1  10.10.10.10/32    110         2.15.1.15     xe5             0
      2.10.1.10      xe11         0
#
```

show ip isis route detail

Use this command to display the MPLS information (ILM-ID, FTN-ID, In-label & Out-label) of the specified IS-IS IPv4 route or all the IS-IS IPv4 routes.

Command Syntax

```
show ip isis (WORD|) route ((prefix A.B.C.D/M)|) detail
```

Parameters

WORD

Information for a single ISIS area.

Prefix

Prefix.

A.B.C.D/M

IPv4 prefix.

Command Mode

Privileged exec mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Example

The following example displays the MPLS information of the specified prefix.

```
#show ip isis route prefix 10.10.10.10/32 detail
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 100: VRF : default
      Destination      Metric      ILM-ID      FTN-ID      In-Label      Next-Hop
      Interface        Tag        Out-Label
L1  10.10.10.10/32    110         3           1           16010         2.15.1.15
      xe5              0          16010
                                   2.10.1.10
      xe11              0          16010
      Src: 0000.0000.0010 Ifindex 10011
      Src: 0000.0000.0010 Ifindex 10005
#
When the command is executed without prefix parameter, MPLS information of all the IS-IS prefixes are
displayed

#show ip isis route detail
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 100: VRF : default
      Destination      Metric      ILM-ID      FTN-ID      In-Label      Next-Hop
      Interface        Tag        Out-Label
C    2.2.2.2/32        10         1           --           16002         --
      lo              0         --
      Src: Connected IS-IS Interface
C    2.10.1.0/24       100        --           --           --           --
      xe11             0         --
      Src: Connected IS-IS Interface
```



```

C    2.15.1.0/24      50      --      --      --      --
    xe5              0      --
    Src: Connected IS-IS Interface
L1  10.10.10.10/32    110      3      1      16010    2.15.1.15
    xe5              0      16010
                                2.10.1.10
    xe11             0      16010
    Src: 0000.0000.0010 Ifindex 10011
    Src: 0000.0000.0010 Ifindex 10005
L1  10.15.1.0/24      100      --      --      --      2.15.1.15
    xe5              0      --
    Src: 0000.0000.0015 Ifindex 10005
L1  15.15.15.15/32    60      5      2      16015    2.15.1.15
    xe5              0      16015
    Src: 0000.0000.0015 Ifindex 10005
#

```

show ip isis route tilfa prefix A.B.C.D/M

Use this command to display the MPLS information (SR outgoing label, PQ node, Backup outgoing label, Bypass trunk ID, Backup out-interface & Protection-type) of all ECMP next-hops of the specified IPv4 prefix. This is an enhancement to the existing command `show ip isis route tilfa` to insert `prefix` as an optional parameter.

Command Syntax

```
show ip isis route (WORD|) tilfa ((prefix A.B.C.D/M)|)
```

Parameters

WORD

Information for a single ISIS area.

Prefix

Prefix.

A.B.C.D/M

IPv4 prefix.

Command Mode

Privileged exec mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Example

```
#show ip isis route tilfa prefix 10.10.10.10/32

Tag : 100 VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2,
        C - Connected Routes, ia - IS-IS inter area

10.10.10.10/32
Route type: L1, FTN-ix :1 ILM-ix :3
SR Incoming Label : 16010
Primary Path Nexthop : 2.10.1.10, xe11
SR outgoing Label : 16010
PQ node : 15.15.15.15
Backup outgoing Label: 16010
Bypass_trunk id : 2202
Backup out interface : xe5
Protection Type : Link Protecting
Primary Path Nexthop : 2.15.1.15, xe5
SR outgoing Label : 16010
PQ node : 10.10.10.10
Backup outgoing Label: 3
Bypass_trunk id : 2201
Backup out interface : xe11
Protection Type : Node Protecting

Trunk : 2201 :10.10.10.10_nh_10011_ALGO FTN-ix : 3 ref_cnt:3
Number Of outgoing label : 1
16010
Nexthop address : 2.10.1.10

#
```

show isis tilfa pq (WORD|)

Use this command to display the PQ nodes of all the ECMP next-hops of the specified vertex. This is an enhancement to the `isis tilfa pq` command to insert `system-id/hostname` as an optional parameter.

Command Syntax

```
show isis (WORD|) tilfa pq (WORD|)
```

Parameters

WORD

Information for a single ISIS area.

WORD

System-ID xxxx.xxxx.xxxx or hostname.

Command Mode

Privileged exec mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Example

When the command is executed by specifying `system-id` parameter:

```
#show isis tilfa pq 7010.00-00

Tag 100: Level-1 Link State Database:

Node: 7010.00-00
Interface xe5
  P node: 0000.0000.0010 primary dist:100
  P node: 0000.0000.0015 primary dist:150
  Q node: 0000.0000.0010
  Q node: 0000.0000.0015
  Node Protecting P Nodes
  P node: 0000.0000.0010 primary dist:100

  PQ Node: 7010.00-00 backup dist:100
  PQ Node (Node Protection): 7010.00-00 backup dist:100
Interface xell
  P node: 0000.0000.0010 primary dist:100
  P node: 0000.0000.0015 primary dist:50
  Q node: 0000.0000.0010
  Q node: 0000.0000.0015
  Node Protecting P Nodes
  P node: 0000.0000.0015 primary dist:50

  PQ Node: 7015.00-00 backup dist:50
  No PQ Node found on backup path (Node Protection)
#
```

When the command is executed by specifying `hostname` parameter:

```
#show isis tilfa pq 7010

Tag 100: Level-1 Link State Database:
```

```
Node: 7010.00-00
Interface xe5
P node: 0000.0000.0010 primary dist:100
P node: 0000.0000.0015 primary dist:150
Q node: 0000.0000.0010
Q node: 0000.0000.0015
Node Protecting P Nodes
P node: 0000.0000.0010 primary dist:100

PQ Node: 7010.00-00 backup dist:100
PQ Node (Node Protection): 7010.00-00 backup dist:100
Interface xe11
P node: 0000.0000.0010 primary dist:100
P node: 0000.0000.0015 primary dist:50
Q node: 0000.0000.0010
Q node: 0000.0000.0015
Node Protecting P Nodes
P node: 0000.0000.0015 primary dist:50

PQ Node: 7015.00-00 backup dist:50
No PQ Node found on backup path (Node Protection)
#
```

show ip ospf route detail

Use this command to display the MPLS information (ILM-ID, FTN-ID, In-label & Out-label) of the specified OSPF IPv4 route or all the OSPF IPv4 routes.

Command Syntax

```
show ip ospf (<0-65535>|) route (((A.B.C.D | A.B.C.D/M |) detail) | )
```

Parameters

<0-65535>

Router process identifier.

A.B.C.D

Single route.

A.B.C.D/M

Single exact match route.

Command Mode

Privileged exec mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Example

The following example displays the MPLS information of all the OSPFv2 routes if a prefix parameter is not specified.

```
#show ip ospf route detail

OSPF process 100:
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
```

ID	Destination In-Label	Metric Out-Label	Nextthop	Interface	Area	ILM-ID	FTN-
C	2.2.2.2/32	1	connected	lo	0.0.0.0		
C	2.10.1.0/24	100	connected	xe11	0.0.0.0		
C	2.15.1.0/24	50	connected	xe5	0.0.0.0		
O	10.10.10.10/32	101	2.10.1.10	xe11	0.0.0.0	8	5
	19010	19010					
			2.15.1.15	xe5	0.0.0.0	8	5
	19010	19010					
O	10.15.1.0/24	100	2.15.1.15	xe5	0.0.0.0		
O	15.15.15.15/32	51	2.15.1.15	xe5	0.0.0.0	10	6
	19015	19015					

```
#
```

The following example displays the MPLS information of the specified OSPFv2 route if a prefix parameter is specified:

```
#show ip ospf route 10.10.10.10/32 detail
```

OSPF process 100:
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

	Destination	Metric	Nexthop	Interface	Area	ILM-ID	FTN-
ID	In-Label	Out-Label					
O	10.10.10.10/32	101	2.10.1.10	xe11	0.0.0.0	8	5
	19010	19010					
			2.15.1.15	xe5	0.0.0.0	8	5
	19010	19010					

show hsl hw unit 0 encap-db LSP_ENCAP_ID

Use this command to display information on the `lsp_encap` entry installed in the hardware. This is an enhancement to the `show hsl hw unit 0 encap-db` command to insert `LSP_ENCAP_ID` as an optional parameter.

Command Syntax

```
show hsl hw unit 0 encap-db (LSP_ENCAP_ID|)
```

Parameters

LSP_ENCAP_ID

LSP Encap ID

Command Mode

Privileged exec mode

Applicability

This command was introduced in OcNOS version 6.5.3.

Example

```
#show hsl hw unit 0 encap-db 0x40002044
label_array[0]:
Entropy enabled      : NO
flags                : 8229(0x2025)
flags2               : 0(0x0)
label                : 16010
qos_map_id           : 537133060
exp                  : 0
ttl                  : 64
pkt_pri              : 0
pkt_cfi              : 0
tunnel_id            : 1073750084(0x40002044)
l3_intf_id           : 4106(0x100a)
MPLS labelaction     : BCM_MPLS_EGRESS_ACTION_PUSH
egress_failover_id   : 0(0x0)
egress_failover_if_id : 0(0x0)
outlif_counting_profile : 0(0x0)
spl_label_push_type   : bcmMplsSpecialLabelPushNone
encap_access          :
estimated_encap_size  : 0(0x0)
#
```

Below are the revised commands. For more details, refer to the [Segment Routing Commands \(page 956\)](#) chapter.

- [show ip isis route tilfa \(page 974\)](#)
- [show isis tilfa pq \(page 976\)](#)
- [show hsl mpls tunnel \(tunnel-id VALUE|\) \(page 973\)](#)
- [show ip ospf tilfa-backup-path \(page 980\)](#)
- [show ip ospf tilfa-repair-list \(page 981\)](#)

Troubleshooting

1. If SR ILM entry is not installed as ECMP in hardware:
 - Check if `mpls ilm-ecmp sr` command is enabled.
 - Check if ECMP next-hops exist for that FEC in ISIS route table `show ip isis route detail` or OSPF route table `show ip ospf route detail`
2. If SR FTN entry is not installed as ECMP in hardware:
 - Check if `mpls ftn-ecmp sr` command is enabled.
 - Check if ECMP next-hops exist for the FEC in ISIS route table `show ip isis route detail` or OSPF route table `show ip ospf route detail`.
3. If traffic is not load-balanced among the ECMP next-hops:
 - Increase the number of flows, as load balancing depends on the internal hash computed by BCM. Note that lesser flows may lead to the same outgoing interface for different flows.

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
Label switched path (LSP)	A sequence of routers that co-operatively perform MPLS operations for a packet stream.
Topology-Independent Loop-Free Alternate (TI-LFA)	The ability to provide a loop free backup path irrespective of the topologies used in the network.
FEC-to-NHLFE (FTN)	A mapping from the forwarding equivalence class (FEC) of incoming packets to the corresponding Next Hop Label Forwarding Entry (NHLFE) in MPLS.
Incoming Label Map (ILM)	A mapping from incoming labels to corresponding Next Hop Label Forwarding Entry (NHLFE) in MPLS.
Interior Gateway Protocol (IGP)	An intra-domain protocol used to exchange network reachability and routing information among devices.
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.

Service Mapping for Segment Routing

Overview

Segment Routing (SR) Service Mapping feature enables dynamic traffic steering by leveraging both native Segment Routing FTN and SR policies. This approach allows different services to reach the same destination while following distinct routing paths optimized for performance, reliability, and scalability.

The need for SR Service Mapping arises when multiple services require tailored routing strategies. While native SR FTN provides a straightforward label-based forwarding mechanism, SR policies introduce enhanced traffic engineering capabilities such as:

- Path Optimization – Selecting the most efficient path based on network conditions.
- Load Balancing – Distributing traffic across multiple paths to prevent congestion.
- Redundancy and Fail-over – Ensuring service continuity in case of link failures.

SR Service Mapping operates through two primary mechanisms:

Native SR FTN:

- Standard SR labels are mapped directly to the forwarding table for default or simple routing paths.
- Traffic follows IGP-calculated shortest paths without additional policies.

SR Policy:

- Custom traffic engineering rules dictate how specific traffic types are routed.
- Enables fine-grained path selection, ensuring latency-sensitive or high-priority services take the most optimized routes.

This dual mechanism provides granular control over network traffic, allowing service providers to allocate network resources efficiently.

Feature Characteristics

The main characteristics of SR Mapping are as follows:

- Flexible Routing Control: Supports both default SR FTN and policy-based routing for differentiated services.
- Traffic Engineering Optimization: Ensures efficient bandwidth utilization with automated path computation.
- Scalability: Works seamlessly with MPLS services, EVPN, and Segment Routing-MPLS (SR-MPLS).
- High Availability & Redundancy: Supports fast reroute mechanisms for seamless failover.
- Interoperability: Fully integrates with existing SR and MPLS architectures.

Benefits

The key benefits of SR Mapping are as follows:

- Optimized Traffic Flow – Routes services based on priority, latency, and bandwidth needs.
- Improved Network Efficiency – Minimizes congestion and enhances overall network performance.
- Simplified Operations – Reduces complexity by leveraging a unified SR-based framework.
- High Availability – Provides redundancy through SR policies, ensuring uninterrupted service.

Prerequisites

The SR Mapping feature can be enabled on the following devices:

- OcNOS devices that support ISIS/OSPF Segment Routing.
- OcNOS devices that support MPLS services such as VPLS, VPWS, L3VPN, 6PE, 6VPE and EVPN (ELINE, ELAN, ETREE).

Configuration

The following configuration enables with SR service mapping.

Topology

This topology represents a basic SR Service Mapping topology:

Figure 47. SRv4 with ISIS Topology



- Provider Edge Router 1 (PE1): Ingress SR router, maps services to SR Policies.
- Core Router (P1): Transit SR router, forwards based on ISIS-SR advertisements.
- Provider Edge Router 2 (PE2): Egress SR router, handles service termination.

Traffic Flow:

- Traffic enters PE1 (ingress).
- PE1 maps services to an SR policy (TE path or native SR forwarding) or vice versa.
- The traffic traverses P1 (core router).
- PE2 (egress) receives the mapped traffic and forwards it accordingly.

To configure SR Mapping functionality on PE nodes with ISIS, follow the steps mentioned below:

1. Configure Loopback for SR.

- Assign a loopback IP and enable IS-IS for routing
- Configure Prefix-SID for Segment Routing.

```

PE1(config)# interface lo
PE1(config-if)# ip address 1.1.1.1/32 secondary
PE1(config-if)# ip router isis 1
PE1(config-if)# prefix-sid index 1 no-php
PE1(config-if)# exit
PE1(config)# commit.

```

2. Assign IP address and enable IS-IS and MPLS on the interface:

```

PE1(config)# interface xe9
PE1(config-if)# ip address 10.1.1.1/30
PE1(config-if)# ip router isis 1
PE1(config-if)# label-switching
PE1(config-if)# commit

```

3. Enable IS-IS as the IGP and configure it to support Segment Routing MPLS.

```

PE1(config)# router isis 1
PE1(config-router)# metric-style wide
PE1(config-router)# is-type level-1-2
PE1(config-router)# net 49.0000.0100.0000.1001.00
PE1(config-router)# mpls traffic-eng level-1
PE1(config-router)# mpls traffic-eng level-2
PE1(config-router)# dynamic-hostname
PE1(config-router)# capability cspf
PE1(config-router)# isis segment-routing global block 16000 23999
PE1(config-router)# segment-routing mpls
PE1(config-router)# commit

```

4. Enable Segment Routing Traffic Engineering and define Policy for Service Mapping, and use IS-IS for path computation.

```

PE1(config)#segment-routing
PE1(config-sr)#traffic-engineering
PE1(config-sr-te)#policy P1
PE1(config-sr-pol)#color 1 end-point 3.3.3.3
PE1(config-sr-pol)#candidate-path 1
PE1(config-sr-pol-cp)#dynamic-path isis 1
PE1(config-sr-pol-cp)#commit
PE1(config-sr-pol-cp)#end

```

5. Enable EVPN VRF over MPLS and configure VTEP IP for service mapping.

```

PE1(config)#mac vrf evpn1
PE1(config-vrf)#rd 1:1
PE1(config-vrf)#route-target both 1:1
PE1(config-vrf)#commit
PE1(config-vrf)#end
PE1(config)#evpn mpls enable
PE1(config)#evpn mpls vtep-ip-global 1.1.1.1
PE1(config)#evpn mpls id 1
PE1(config-evpn-mpls)#host-reachability-protocol evpn-bgp evpn1
PE1(config-evpn-mpls)#exit

```

6. Enable BGP EVPN for service mapping.

```

PE1(config)#router bgp 65010
PE1(config-router)#neighbor 3.3.3.3 remote-as 65010
PE1(config-router)#neighbor 3.3.3.3 update-source lo
PE1(config-router)#address-family l2vpn evpn
PE1(config-router-af)#neighbor 3.3.3.3 activate
PE1(config-router-af)#commit
PE1(config-router-af)#end

```



Note: Ensure EVPN routes are exchanged between PE1 and PE2.

7. Configure Access Interface for EVPN

```

PE1(config)#interface xe2.1 switchport
PE1(config-if)#encapsulation dot1q 10
PE1(config-if)#access-if-evpn
PE1(config-acc-if-evpn)#map vpn-id 1
PE1(config-acc-if-evpn)#commit

```

8. Define Tunnel Selection Policy for SR services.

```

PE1(config)#tunnel-policy 1
PE1(config-tnl-policy)#color 1
PE1(config-tnl-policy)#commit
PE1(config-tnl-policy)#end

```

9. Bind Tunnel Policy to EVPN MPLS or other services like vrf

```
PE1(config)#evpn mpls id 1
PE1(config-evpn-mpls)#tunnel-select-policy 1
PE1(config-evpn-mpls)#commit
PE1(config-evpn-mpls)#end
or
PE1(config)#mac vrf evpn1
PE1(config-vrf)#tunnel-select-policy 1
PE1(config-vrf)#commit
```

Configuration Snapshot

PE1

Configuration Snapshot of PE1

```
!
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 voq-full-color enable
hardware-profile statistics cfm-ccm enable
!
qos enable
!
hostname PE1
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
!
evpn mpls enable
!
tunnel-policy 1
color 1
!
ip vrf management
!
mac vrf evpn1
rd 1:1
route-target both 1:1
!
evpn mpls vtep-ip-global 1.1.1.1
!
evpn mpls id 1
host-reachability-protocol evpn-bgp evpn1
tunnel-select-policy 1
!
segment-routing
traffic-engineering
```

```
policy P1
  color 1 end-point 3.3.3.3
  candidate-path 1
    dynamic-path isis 1
  exit-pol-cp
  !
  exit-sr-pol
  !
  exit-te
  !
interface ce0
  !
interface ce1
  !
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
  prefix-sid index 1 no-php
  ip router isis 1
  !
interface lo.management
  ip vrf forwarding management
  ip address 127.0.0.1/8
  ipv6 address ::1/128
  !
interface xe2
  !
interface xe2.1 switchport
  encapsulation dot1q 10
  access-if-evpn
  map vpn-id 1
  !
interface xe3
  !
interface xe7
  speed 10g
  !
interface xe8
  !
interface xe9
  speed 10g
  ip address 10.1.1.1/30
  label-switching
  ip router isis 1
  !
interface xe10

!
exit
!
router isis 1
  is-type level-1-2
  metric-style wide
  mpls traffic-eng level-1
  mpls traffic-eng level-2
  capability cspf
  dynamic-hostname
  net 49.0000.0100.0000.1001.00
  isis segment-routing global block 16000 23999
  segment-routing mpls
  !
router bgp 65010
  neighbor 3.3.3.3 remote-as 65010
```

```
neighbor 3.3.3.3 update-source lo
!
address-family l2vpn evpn
neighbor 3.3.3.3 activate
exit-address-family
#
```

P1

Configuration Snapshot of P1

```
!
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 P1
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
!
interface ce0
!
interface ce1
!
interface ce2
!
interface ce3
!
interface ce4
!
interface ce5
!
interface eth0
ip vrf forwarding management
ip address 192.168.3.10/24
!
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 lo.management  
  ip vrf forwarding management  
  ip address 127.0.0.1/8  
  ipv6 address ::1/128  
!  
interface xe0  
!  
interface xe1  
!  
interface xe2  
!  
interface xe3  
!  
interface xe4  
!  
interface xe5  
!  
interface xe6  
  ip address 10.1.1.2/30  
  label-switching  
  ip router isis 1  
!  
interface xe7  
  ip address 11.1.1.1/30  
  label-switching  
  ip router isis 1  
!  
interface xe8  
!  
interface xe9  
!  
interface xe10  
!  
interface xe11  
!  
  exit  
!  
router isis 1  
  is-type level-1-2  
  metric-style wide  
  mpls traffic-eng level-1  
  mpls traffic-eng level-2  
  capability cspf  
  dynamic-hostname  
  net 49.0000.0100.0000.1002.00  
  isis segment-routing global block 16000 23999  
  segment-routing mpls  
!  
end
```

PE2

Configuration Snapshot of PE2

```
!  
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 voq-full-color enable  
hardware-profile statistics cfm-ccm 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  
!  
evpn mpls enable  
!  
ip vrf management  
!  
mac vrf evpn1  
  rd 1:1  
  route-target both 1:1  
!  
evpn mpls vtep-ip-global 3.3.3.3  
!  
evpn mpls id 1  
  host-reachability-protocol evpn-bgp evpn1  
!  
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  
  prefix-sid index 3 no-php  
  ip router isis 1  
!  
interface lo.management  
  ip vrf forwarding management  
  ip address 127.0.0.1/8  
  ipv6 address ::1/128  
!  
interface xe2  
!  
interface xe3  
!  
interface xe3.1 switchport  
  encapsulation dot1q 10  
  access-if-evpn  
  map vpn-id 1  
!  
interface xe4  
!  
interface xe5  
  ip address 11.1.1.2/30  
  label-switching
```



```

ip router isis 1
!
interface xe6
!
interface xe7
!
interface xe8
!
interface xe9
!
interface xe10
!
interface xe11
!
interface xe12
!
interface xe13
!
exit
!
router isis 1
 is-type level-1-2
 metric-style wide
 mpls traffic-eng level-1
 mpls traffic-eng level-2
 capability cspf
 dynamic-hostname
 net 49.0000.0100.0000.1003.00
 isis segment-routing global block 16000 23999
 segment-routing mpls
!
router bgp 65010
 neighbor 1.1.1.1 remote-as 65010
 neighbor 1.1.1.1 update-source lo
!
 address-family l2vpn evpn
 neighbor 1.1.1.1 activate
 exit-address-family
!
exit
!
!
end

```

Validation

Verify ISIS neighbor adjacency between routers.

```

PE1#show clns neighbors ()

Total number of L1 adjacencies: 1
Total number of L2 adjacencies: 1
Total number of adjacencies: 2
Tag 1: VRF : default

```

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
P1	xe9	80a2.355b.7008	Up	21	L1	IS-IS
			Up	21	L2	IS-IS

Verify that segment routing is enabled and that prefix SIDs are announced to other routers and verify that prefix SIDs are installed as labels in MPLS forwarding table. Verify the same in FTN and ILM tables.

```

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, SR: Disabled

Code	FEC	FTN-ID	Nhlfe-ID	Tunnel-ID	Pri	Out-Label	Out-
Intf	ELC	Nexthop	Algo-Num	UpTime			
i>	2.2.2.2/32	1	8	-	-	-	-
	-	0	00:20:23	5	0	Yes	16002 xe9 No
10.1.1.2	-	-	13	1	Yes	16003	xe9 No
P>	3.3.3.3/32	3	00:17:21	10	-	-	-
10.1.1.2	N/A	2	00:19:07	9	0	Yes	16003 xe9 No
i>	3.3.3.3/32	0					
	-						
10.1.1.2	-	-					

Verify SR policy

```
PE1#show segment-routing policy
```

Policy-Name	State	Forwarding-Info	Color	End-
point				
P1			1	3.3.3.3 UP
16003/xe9				
Verify EVPN ELAN servic				

Verify EVPN ELAN service:

```
PE1#show evpn mpls tunnel
```

Source	Destination	Status	Up/Down	Update	evpn-id	Local-
Leaf	Remote-Leaf					
1.1.1.1	3.3.3.3	Installed	00:02:46	00:02:46	1	---

show evpn mpls tunnel label

```
PE1-7012#sh evpn mpls tunnel label
```

EVPN-MPLS Network tunnel labels

(*) in Policy - tunnel-policy inherited from mac-vrf

(e) - Service mapped over MPLS Multipath/ECMP

LS-Multipath				Underlay				Local		Remote		MP
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	1	1	27524	28164	27524	--	--				
170	xe9	16014										

Verify the tunnel policy details

Total number of entries are 1

```
PE1#sh tunnel-policy service details-----()
```

List of services configured with tunnel-policy 1:

EVPN

EVPN-Id: 1, Tunnel count: 1

Peer: 3.3.3.3 Mapped Tunnel: P1 [Owner: SR_POLICY], ftn_ix 3, color 1

Implementation Examples

- SR-TE for MPLS VPN Services

- Use SR Policies to optimize L3VPN MPLS services.
- Example: Redirecting VoIP traffic via an SR-TE policy to ensure low latency.
- EVPN Traffic Steering via SR Policies
 - Ensure L2VPN/EVPN services are carried over low-latency paths using SR-TE.
 - Example: Large-scale data center interconnects (DCI).
- Dynamic Traffic Engineering
 - Route specific applications (for example: video traffic) via high-priority TE paths.

Glossary

The following provides definitions for key terms or abbreviations and their meanings used throughout this document:

Key Terms/Acronym	Description
Segment Routing (SR)	A source-routing paradigm that uses Segment Identifiers (SIDs) to define a path through the network without requiring per-flow state in intermediate nodes. SR can be applied to MPLS (SR-MPLS) or IPv6 (SRv6) networks.
SR Policy	A traffic engineering mechanism that allows explicit routing of traffic through a sequence of segments. SR policies enable optimized routing, load balancing, and redundancy.
Forwarding Table Number (FTN)	A table in the router that maps incoming packets to specific Segment Routing (SR) paths or policies based on preconfigured rules.
Multiprotocol Label Switching (MPLS)	A packet-forwarding technology that assigns labels to packets and forwards them based on labels instead of traditional IP routing..
Interior Gateway Protocol (IGP)	An intra-domain protocol used to exchange network reachability and routing information among devices.

Deep Packet Inspection

Overview

Deep Packet Inspection (DPI) performs a granular check on the inner headers beyond the MPLS bottom of 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 (Q1) series platforms, and a system reboot is required after enabling and disabling the feature. In Qumran2 (Q2) series platforms, it is always enabled by default.

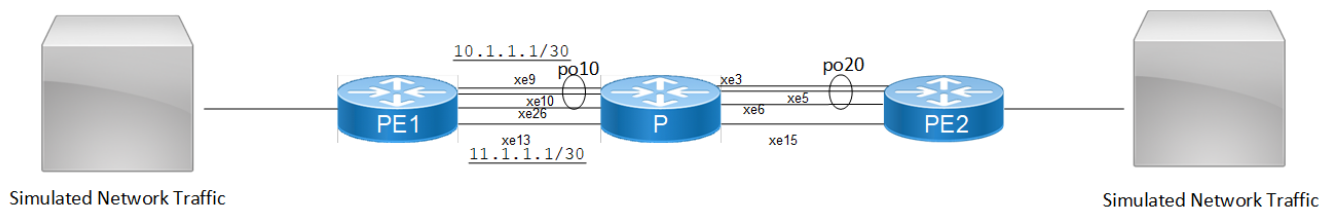
Benefits

The DPI feature optimizes network performance by preventing traffic congestion by distributing traffic across available pathways.

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).

Figure 48. DPI Configuration



DPI Configuration

Follow the steps to configure the DPI on Qumran1 (Q1) 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 neighborhood 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 vpv4 unicast
(config-router-af)#neighbor 6.6.6.6 activate
(config-router-af)#exit-address-family
(config-router)# address-family vpv6 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 (Q1) series platforms.

```
(config)#advanced parser enable
```



Note: DPI is enabled by default on Qumran2 (Q2) 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 neighborhood 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 (Q1) series platforms.

```
(config)#advanced parser enable
```



Note: DPI is enabled by default on Qumran2 (Q2) series platforms.

PE2

1. Configure IP address secondary on the loopback interface

```
(config)#interface lo
(config-if)#prefix-sid index 6 no-php
```

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 neighborhood 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 (Q1) series platforms.

```
(config)#advanced parser enable
```



Note: DPI is enabled by default on Qumran2 (Q2) 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

PE1

Validate the show output after configuration as shown below.

```
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
                xe13      80a2.35ec.d66f    Up     26        L2    IS-IS
0000.0001.0002 po10      80a2.35ec.d699    Up     20        L1    IS-IS
                po10      80a2.35ec.d699    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					
1.2	No	-	20002	3	N/A	po10	10.1.
1.2	Yes	-	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      -      20006      20006      N/A      xe13      11.1.
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      |
+-----+-----+-----+-----+-----+
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

Validate the show output after configuration as shown below.

```

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	-	20003	20003	N/A	po10	10.1.
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	-	20002	NoLabel	N/A	N/A	127.0
i>	2.2.2.2/32	1	20006	20006	N/A	po20	12.1.
.0.1	Yes	00:01:40	20006	3	N/A	xe15	13.1.
i>	6.6.6.6/32	7	20006	20006	N/A	po20	12.1.
1.2	Yes	00:01:04	20006	20006	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	-	25602	3	N/A	po20	12.1.
i>	12.1.1.2/32	4	25602	20006	N/A	xe15	13.1.
1.2	Yes	00:01:17	25601	3	N/A	xe15	13.1.
1.2	No	-	25601	20006	N/A	po20	12.1.
i>	13.1.1.2/32	3	25601	3	N/A	po10	10.1.
1.2	Yes	00:01:18	25603	3	N/A	xe13	11.1.
1.1	No	-	25603	20003	N/A	xe13	11.1.

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 pps
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

Validate the show output after configuration as shown below.

```
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          Nexthop      FTN-ID  Nhlfe-ID  Tunnel-ID  Pri  Out-Label  Out-
Intf   ELC           UpTime
i>     2.2.2.2/32      1          51      -          (e)      -      -          -
      -              00:01:40
      13.1.1.1        -          4        0        Yes      20002      xe15      Yes
      No             3          po20      2        Yes      12.1.1.1      -      po20      Yes
      12.1.1.1        -          3        -          Yes      20002      po20
      No             3          xe15      Yes      13.1.1.1      -
i
(b)>   2.2.2.2/32      3          2201     Yes      20002      po20      No
      12.1.1.1        00:01:38
i
(b)>   2.2.2.2/32      4          2202     Yes      20002      xe15      No
      13.1.1.1        00:01:38
i>     3.3.3.3/32      2          53      -          (e)      -      -          -
      -              00:01:40
      13.1.1.1        -          16       0        Yes      20003      xe15      Yes
      No             20003      po20      Yes      12.1.1.1      -      po20      Yes
      12.1.1.1        -          17       0        Yes      20003      po20
      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          |          |         |          |         |
+-----+-----+-----+-----+-----+
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    |

```

CLI Commands

The DPI feature introduces the following configuration command.

advanced parser enable

Use this command to enable the DPI on Qumran1 (Q1) series platforms.

Command Syntax

```
advanced parser enable
```

Parameters

None

Default

None

Command Mode

Configure mode

Applicability

Introduced in [Global-variable.OcNOS SPv6.5.3] and applicable to Qumran1 (Q1) series platforms.

Example

This example shows how to enable the DPI on Qumran1 (Q1) 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.

| SEGMENT ROUTING COMMAND REFERENCE

Segment Routing Commands

This section describes each segment routing command.

adjacency-sid

Use this command to add a adjacency segment identifier (adjacency-SID) to the primary address of an interface. You can only configure adjacency-SIDs for point-to-point links and not for broadcast links.

Use the `no` form of this command to remove an adjacency-SID.

Command Syntax

```
adjacency-sid (isis(absolute <16-1048575>|index <0-1048575>)|ospf(absolute <16-1048575>|index <0-1048575>))  
no adjacency-sid (isis|ospf)
```

Parameters

isis

Associates the Adjacency SID with the IS-IS routing process.

ospf

Associates the Adjacency SID with the OSPF routing process.

absolute

Specifies the absolute value with the OSPF/ISIS routing process.

index

Specifies the index value with the OSPF/ISIS routing process.

16-1048575

Specifies the SID absolute-value with the OSPF/ISIS routing process.

0-1048575

Specifies the SID index-value with the OSPF/ISIS routing process.

Defaults

N/A

Command Mode

Interface mode

Applicability

This command was introduced in OcNOS version 6.1.0. Added parameters `isis`, and `ospf` in OcNOS version 6.6.1.

Example

```
#configure terminal  
(config)#interface ce4
```



```
(config-if)#ip address 16.0.0.20/24
(config-if)#adjacency-sid ospf absolute 1048500
(config-if)#commit
(config-if)#exit

#configure terminal
(config)#interface ce4
(config-if)#ip address 16.0.0.20/24
(config-if)#label-switching
(config-if)#ip ospf network point-to-point
(config-if)#adjacency-sid isis index 1000
(config-if)#commit
(config-if)#exit
```

advanced parser enable

Use this command to enable the DPI on Qumran1 (Q1) 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 (Q1) series platforms.

Example

This example shows how to enable the DPI on Qumran1 (Q1) series platforms:

```
OcNOS#configure terminal
OcNOS#(config)#advanced parser enable
OcNOS#(config)#commit
```

clear mpls counters isis-segment-routing

Use this command to clear traffic statistics for isis-segment-routing FTNs and ILMs.

Command Syntax

```
clear mpls counters isis-segment-routing (ftn (|A.B.C.D/M) | ilm (|A.B.C.D/M))
```

Parameters

isis-segment-routing

isis segment-routing ftn's/ilm statistics

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 4.0.

Example

```
#clear mpls counters isis-segment-routing ftn
#clear mpls counters isis-segment-routing ilm
```

clear mpls counters ospf-segment-routing

Use this command to clear traffic statistics for ospf-segment-routing FTNs and ILMs.

Command Syntax

```
clear mpls counters ospf-segment-routing (ftn (|A.B.C.D/M) | ilm (|A.B.C.D/M))
```

Parameters

ospf-segment-routing

ospf segment-routing ftn's/ilm statistics

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 4.0.

Example

```
#clear mpls counters ospf-segment-routing ftn
#clear mpls counters ospf-segment-routing ilm
```

clear mpls counters sr-policy

Use this command to clear traffic statistics for sr-policy.

Command Syntax

```
clear mpls counters sr-policy ((policy-name NAME) |)
```

Parameters

policy-name

segment-routing policy name

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#clear mpls counters sr-policy
#clear mpls counters sr-policy policy-name p1
```

debug ip ospf tilfa

Use this command to enable debugging for OSPF Topology-Independent Loop-Free Alternate (TI-LFA).

Use the `no` form of this command to disable debugging for OSPF TI-LFA.

Command Syntax

```
debug ip ospf tilfa
no debug ip ospf tilfa
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.1.

Example

```
#debug ip ospf tilfa
```

debug isis sr

Use this command to enable debugging for ISIS segment routing.

Use the `no` form of this command to disable debugging for ISIS segment routing.

Command Syntax

```
debug isis sr  
no debug isis sr
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#debug isis sr
```

debug isis tilfa

Use this command to enable debugging for ISIS Topology-Independent Loop-Free Alternate (TI-LFA).

Use the `no` form of this command to disable debugging for ISIS TI-LFA.

Command Syntax

```
debug isis tilfa  
no debug isis tilfa
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.1.

Example

```
#debug ospf tilfa
```

debug ospf sr

Use this command to enable debugging for OSPF segment routing.

Use the `no` form of this command to disable debugging for OSPF segment routing.

Command Syntax

```
debug ospf sr
debug ip ospf all
no debug ospf sr
no debug ip ospf all
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#debug ospf sr
```

fast-reroute per-prefix ti-lfa area (OSPFv2)

Use this command to enable Topology-Independent Loop-Free Alternate (TI-LFA) per area. TI-LFA uses segment routing to provide link, node, and Shared Risk Link Groups (SRLG) protection in topologies where other fast reroute techniques, such as RLFA (Remote Loop Free Alternative) cannot provide protection.

Use the `no` form of this command to disable TI-LFA.

Command Syntax

```
fast-reroute per-prefix ti-lfa area (A.B.C.D|<0-4294967295>)
no fast-reroute per-prefix ti-lfa area (A.B.C.D|<0-4294967295>)
```

Parameters

A.B.C.D

OSPF area ID in IPv4 address format.

<0-4294967295>

OSPF area ID as a decimal value.

Default

TI-LFA is disabled.

Command Mode

OSPF router mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#router ospf 1
(config-router)#fast-reroute per-prefix ti-lfa area 2
(config-router)#no fast-reroute per-prefix ti-lfa area 2
```

fast-reroute ti-lfa (ISIS)

Use this command to enable Topology-Independent Loop-Free Alternate (TI-LFA) per level. TI-LFA uses segment routing to provide link, node, and Shared Risk Link Groups (SRLG) protection in topologies where other fast reroute techniques, such as RLFA (Remote Loop Free Alternative) cannot provide protection.

Use the `no` form of this command to disable TI-LFA.

Command Syntax

```
fast-reroute ti-lfa (level-1 | level-2) proto ipv4
no fast-reroute ti-lfa (level-1 | level-2) proto ipv4
```

Parameters

level-1

Level 1 only.

level-2

Level 2 only.

Default

TI-LFA is disabled.

Command Mode

ISIS router mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#router isis 100
(config-router)#fast-reroute ti-lfa level-2 proto ipv4
(config-router)#no fast-reroute ti-lfa level-2 proto ipv4
```

global block

Use this command to configure a segment routing global block (SRGB).

Use the `no` form of this command to remove segment-routing global block.



Notes:

- The allocation of the desirable SRGB will depend upon the availability of the desirable pool. If there is any conflict or any protocol is already using any label/pool of labels which is falling between SRGB range, SRGB will not be allocated and an error will be prompted.
- You cannot configure a SRGB for an IGP instance which is outside globally configured SRGB (or default SRGB if SRGB is not configured). An error will be returned if you configure [segment-routing mpls \(page 972\)](#) and try to use a block outside the globally configured SRGB (default range is 16000-23999).
- You cannot remove a globally configured SRGB if any IGP instance has SRGB configured locally and being used.
- You can modify SRGB only if the newly configured SRGB range does not affect any IGP instance having local SRGB configuration. A newly configured SRGB must include an IGP configured SRGB range.
- If you have not configured SRGB inside an IGP instance and has [segment-routing mpls \(page 972\)](#) configuration configured, any change in global SRGB configuration will take into effect at IGP instance level only after the user toggles [segment-routing mpls \(page 972\)](#) configuration.
- The maximum allowed block size for SRGB is 262143 (25% of complete label pool).

Command Syntax

```
global block <16-1048575> <16-1048575>
no global block
```

Parameters

<16-1048575>

SRGB start and end values

Default

Start value of SRGB range: 16000

End value of SRGB range: 23999

Command Mode

Segment routing mode

Applicability

This command was introduced in OcNOS version 4.0 and the SRGB range changed in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#global block 17000 18000
(config-sr)#
```

isis segment-routing global block

Use this command to set the Segment Routing Global Block (SRGB) range at each node. The SRGB is the range of labels reserved for segment routing. In MPLS, SRGB is the set of labels reserved for global segments.

SRGB range must be configured as non-overlapping range for each IGP instances and also for each IGP protocols. IGP protocols must use SRGB range within the globally configured SRGB value or default SRGB value if no global SRGB is configured.

Use the `no` form of this command to remove an SRGB range. Segment routing must be disabled before removing a particular range.

Command Syntax

```
isis segment-routing global block <16-1048575> <16-1048575>
no isis segment-routing global block
```

Parameters

<16-1048575>

Start and end values of the SRGB range

Defaults

Start value of SRGB range: 16000

End value of SRGB range: 23999

Command Mode

ISIS router mode

Applicability

This command was introduced in OcNOS version 4.0 and the SRGB range changed in OcNOS version 6.1.0.

Example

```
#configure terminal
```



```
(config)#router isis bb
(config-router)#isis segment-routing global block 17000 19000
```

local block

Use this command to configure a segment routing local block (SRLB).

Use the `no` form of this command to remove a segment routing local block.

Command Syntax

```
local block <16-1048575> <16-1048575>
```



Notes: no local block

Parameters

<16-1048575>

SRLB start and end values

Default

Start value for SRLB range: 14080

End value for SRLB range: 15999

Command Mode

Segment routing mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#global block 10001 20000
(config-sr)#local block 100000 109999
```

mpls sr-prefer

Use this command to prefer segment routing MPLS entries over LDP entries for forwarding.

Use the `no` form of this command to remove this configuration.

Command Syntax

```
mpls sr-prefer
no mpls sr-prefer
```

Parameters

None

Default

By default, mpls sr-prefer is not configured and LDP labels are preferred over SR.

Command Mode

Segment-routing mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#mpls sr-prefer
(config-sr)#
```

ospf segment-routing global block

Use this command to set the Segment Routing Global Block (SRGB) range at each node. The SRGB is the range of labels reserved for segment routing. In MPLS, SRGB is the set of labels reserved for global segments.

SRGB range must be configured as non-overlapping range for each IGP instances and also for each IGP protocols. IGP protocols must use SRGB range within the globally configured SRGB value or default SRGB value if no global SRGB is configured.

Use the no form of this command to remove an SRGB range. Segment routing must be disabled before removing a particular range.

Command Syntax

```
ospf segment-routing global block <16-1048575>
no ospf segment-routing global block
```

Parameters

<16-1048575>

Specifies the SRGB Starting Range values.

Defaults

Start value of SRGB range: 16000

End value of SRGB range: 23999

Command Mode

OSPF router mode

Applicability

This command was introduced in OcNOS version 4.0 and the SRGB range changed in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#router ospf 100
(config-router)#ospf segment-routing global block 17000 19000
```

ping mpls

Use this command to check the connectivity between ingress and egress of LSP. This command uses MPLS echo request and reply messages, similar to Internet Control Message Protocol (ICMP) echo request and reply messages, to validate an LSP.

Segment routing ping is an extension of the MPLS LSP ping to perform connectivity verification on the segment routing control plane. Use this command to check connectivity if an LSP traverses entirely through a segment routing domain.

You can initiate the segment routing ping operation only when the segment routing control plane is available at the originator.

Command Syntax

```
ping mpls (ospf-sr | isis-sr) (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})
```

Parameters

ospf-sr

OSPF

isis-sr

ISIS

ipv4

IPv4 address

A.B.C.D/M

IPv4 prefix address

reply-mode

Reply mode

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

timeout

Time to wait before rejecting the probe as a failure

<1-500>

Timeout in seconds

repeat

Repeat sending of ping packets

<5-5000>

Number of pings to send

interval

Interval between ping packets

<2-20000>

Interval in milliseconds

force-explicit-null

Force Explicit Null label

detail

Print detailed output of the ping

Defaults

Default TTL is 255.

Default timeout is 60 seconds.

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#ping mpls ospf-sr ipv4 10.0.1.33/32 destination 127.1.0.1 flags detail
Sending 5 MPLS Echos to 2.32.0.0, 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

! seq_num = 1 0.0.0.0 1.98 ms
! seq_num = 2 0.0.0.0 1.68 ms
! seq_num = 3 0.0.0.0 1.37 ms
! seq_num = 4 0.0.0.0 1.59 ms
! seq_num = 5 0.0.0.0 1.85 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.37/1.67/1.98
```

ping mpls generic

Use this command to check the connectivity between ingress and egress of LSP. This command uses MPLS echo request and reply messages, similar to Internet Control Message Protocol (ICMP) echo request and reply messages, to validate an LSP.

Use the ping mpls generic command to verify connectivity for an LSP that traverses across multiple-domains, such as segment routing and LDP domains in the case of an SR-LDP interoperability use case.

You can initiate the segment routing ping operation only when the segment routing control plane is available at the originator.

Command Syntax

```
ping mpls generic (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}|)
```

Parameters

ipv4

IPv4 address

A.B.C.D/M

IPv4 prefix address

reply-mode

Reply mode

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

timeout

Time to wait before rejecting the probe as a failure

<1-500>

Timeout in seconds

repeat

Repeat sending of ping packets

<5-5000>

Number of pings to send

interval

Interval between ping packets

<2-20000>

Interval in milliseconds

force-explicit-null

Force Explicit Null label

detail

Print detailed output of the ping

Defaults

Default TTL is 255.

Default timeout is 60 seconds.

Command Mode

Privileged Exec mode

Applicability

This command was introduced in [[[Undefined variable Global-variable.OcNOS-SPv6.0.1]]].

Example

```
#ping mpls generic ipv4 10.0.1.33/32 destination 127.1.0.1 flags detail
Sending 5 MPLS Echos to 2.32.0.0, 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

! seq_num = 1 0.0.0.0 1.98 ms
! seq_num = 2 0.0.0.0 1.68 ms
! seq_num = 3 0.0.0.0 1.37 ms
```

```
! seq_num = 4 0.0.0.0 1.59 ms
! seq_num = 5 0.0.0.0 1.85 ms

Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 1.37/1.67/1.98
```

prefix-sid

Use this command to add a prefix segment identifier (prefix-SID) to the primary address of an interface. A prefix-SID corresponds to an MPLS label.

Use the `no` form of this command to remove a prefix-SID.



Notes:

- You must configure a prefix-SID for each prefix on the interface manually the same as for configuring IP addresses.
- OcNOS does not check whether the SID index or absolute value is within the SRGB's range when the SID is configured on the interface. If you configure an index/absolute value that is out of range of the configured SRGB, you will not see any error message while doing the configuration. An Oper log will be shown when you try to advertise this entry via IGP and the entry will not be advertised/installed if it falls outside the SRGB. While configuring SID value, you must make sure that indices are configured in such a way that they do not exceed the SRGB max value. For example, if the SRGB range is 100000-300000, you must not configure an index beyond 200000 and the absolute SID value must be within 100000-300000.

Command Syntax

```
prefix-sid (absolute <16-1048575>|index <0-1048575>) (explicit-null|no-php|) (n-flag-clear|)
no prefix-sid
```

Parameters

<16-1048575>

Absolute prefix-SID allocated from the Segment Routing Global Block (SRGB).

<0-1048575>

Index prefix-SID if SRGB values are different across segment routing nodes.

explicit-null

Any upstream neighbor of the prefix-SID originator *must* replace the prefix-SID with a prefix-SID having an explicit NULL value (0 for IPv4) before forwarding the packet

no-php

The penultimate hop *must not* pop the prefix-SID before delivering the packet to the node that advertised the prefix-SID

n-flag-clear

The prefix-SID does not represent the node originating the prefix-SID

Defaults

Penultimate hop popping (PHP) is enabled by default if you do not specify the no-php parameter.

Command Mode

Interface mode

Applicability

This command was introduced in OcNOS version 4.0 and the prefix-SID range changed in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#interface loopback0
(config-if)#prefix-sid index 404

#configure terminal
(config)#interface loopback0
(config-if)#prefix-sid absolute 19004 no-php n-flag-clear
```

segment-routing capability entropy

Use this command to enable and configure entropy labels within the Segment Routing framework in ISIS instances.

For more information, see the [segment-routing entropy-label \(page 887\)](#) section in the [Entropy Labels for ISIS or OSPF Segment Routing \(page 883\)](#) chapter.

segment-routing mpls

Use this command to enable MPLS-based segment routing for an ISIS or OSPF process.

Use the `no` form of this command to disable segment routing for an ISIS or OSPF process.

Command Syntax

```
segment-routing mpls
no segment-routing mpls
```

Parameters

None

Defaults

None

Command Mode

OSPF or ISIS router mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#router ospf 100
(config-router)#segment-routing mpls

#configure terminal
(config)#router isis 101
(config-router)#segment-routing mpls
```

show hsl mpls tunnel (tunnel-id VALUE)

Use this command to display all the dependent backup next-hops of the specified tunnel.

Command Syntax

```
show hsl mpls tunnel (tunnel-id VALUE|)
```

Parameters

Tunnel-id

Tunnel ID

VALUE

Value of the Tunnel ID

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0. Enhanced the command for ECMP in OcNOS version 6.5.3.

Example

```
#show hsl mpls tunnel tunnel-id 2201
Tunnel Table
-----
Owner:I Destination FEC:10.10.10.10 Tunnel ID:2201 LSP ID:4 Lsp type:BPS NHLFE ID:17 Out
Label:16010 Phy IfName:xe11 Out_mac:e8c5.7afe.f86b
UP_time:01:40:47 MPLS Ifname:mpls-tp500000 Tunnel mode:ingress Tnl_lock_count:0 Fib_
id:0 Flag:0x0 Entropy:0
NextHop:2.10.1.10 fec:0x2000101d encap-opti:0x2000101f lport:0x800000b lsp_encap:0x40002050 ll_
encap:0x40002051
bkp_info : failover_id 0x0 bkp_ifindex 0 bkp_nhlfe_ix 0
sec_info : failover_id 0x0 sec_ifindex 0 old_sec_ifindex 0 sec_nhlfe_ix 0
primary_lsp_ix 0 primary_nhlfe_ix 0 is_switched_to_bkp 0
Reference Count:5 Prefix count:0 VC count:0 LU-FTN count:0 ILM count:0 L3VPN
RefCount:0 EVPN RefCount:0 SR-BKP-nh count:5
Dependent SR-BKP-NH
BKP : nhlfe_ix:1 out-label:3 out-intf:xe11 NextHop:2.10.1.10
fec:0x2000800b port:0x800000b lsp_encap:0x40002056 ll_encap:0x40002057
BKP : nhlfe_ix:1 out-label:3 out-intf:xe11 NextHop:2.10.1.10
fec:0x2000800f port:0x800000b lsp_encap:0x4000205d ll_encap:0x4000205e
BKP : nhlfe_ix:21 out-label:16015 out-intf:xe11 NextHop:2.10.1.10
fec:0x20008003 port:0x800000b lsp_encap:0x4000204f ll_encap:0x4000205f
BKP : nhlfe_ix:21 out-label:16015 out-intf:xe11 NextHop:2.10.1.10
fec:0x20008001 port:0x800000b lsp_encap:0x40002062 ll_encap:0x40002051
```

```

BKP : nhife_ix:21    out-label:16015    out-intf:xe11    NextHop:2.10.1.10
      fec:0x20008005  port:0x800000b  lsp_encap:0x40002064  ll_encap:0x40002051
#

```

show ip isis route tilfa

Use this command to display the Topology-Independent Loop-Free Alternate (TI-LFA) route. For an IS-IS IPv4 prefix with ECMP next-hops, ISIS will compute a backup for each ECMP next-hop of the prefix. This command displays the MPLS information of all the ECMP next-hops.

Command Syntax

```
show ip isis route (WORD|) tilfa
```

Parameters

WORD

Information for a single ISIS area

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0. Enhanced the command for ECMP in OcNOS version 6.5.3.

Example

```

#show ip isis route tilfa

Tag : 100 VRF : default
Codes : L1 - IS-IS level-1, L2 - IS-IS level-2,
        C - Connected Routes, ia - IS-IS inter area

10.10.10.10/32
  Route type: L1, FTN-ix :1 ILM-ix :3
  SR Incoming Label : 16010
  Primary Path Nexthop : 2.10.1.10, xe11
  SR outgoing Label : 16010
  PQ node : 15.15.15.15
  Backup outgoing Label: 16010
  Bypass_trunk id : 2202
  Backup out interface : xe5
  Protection Type : Link Protecting
  Primary Path Nexthop : 2.15.1.15, xe5
  SR outgoing Label : 16010
  PQ node : 10.10.10.10
  Backup outgoing Label: 3
  Bypass_trunk id : 2201
  Backup out interface : xe11
  Protection Type : Node Protecting

Trunk : 2201 :10.10.10.10_nh_10011_ALGO FTN-ix : 3 ref_cnt:3
Number Of outgoing label : 1
16010
Nexthop address : 2.10.1.10

```

```

15.15.15.15/32
Route type: L1, FTN-ix :2  ILM-ix :5
SR Incoming Label      : 16015
Primary Path Nexthop   : 2.15.1.15, xe5
SR outgoing Label      : 16015
PQ node                : 10.10.10.10
Backup outgoing Label: 16015
Bypass_trunk id        : 2201
Backup out interface   : xe11
Protection Type        : Link Protecting

Trunk : 2202 :15.15.15.15_nh_10005_ALG0  FTN-ix : 4 ref_cnt:2
Number Of outgoing label : 1
16015
Nexthop address : 2.15.1.15

#

```

isis srlg flex-algo

Use this command to configure the flexible algorithm specific link attributes (ASLA) SRLG ID on a ISIS routing enabled interface in Flex-Algo.

Use the `no` parameter of this command to disable the flexible algorithm specific link attributes (ASLA) SRLG ID.

Command Syntax

```

isis srlg flex-algo <SRLG-ID>
[no] isis srlg flex-algo <SRLG-ID>

```

Parameters

<1-4294967295>

SRLG ID to be configured.

Default

None

Command Mode

Interface mode Mode

Applicability

Introduced in OcNOS version 7.0.0.

Example

```

DUT5(config)#
DUT5(config)#int sa50
DUT5(config-if)#isis srlg flex-algo 951
DUT5(config-if)#isis srlg flex-algo 952
DUT5(config-if)#commit
DUT5(config-if)#
DUT5(config-if)#
DUT5(config-if)#int po10

```

```
% Warning: Executing the CLI from higher config mode level
DUT5(config-if)#
DUT5(config-if)#isis srlg flex-algo 953
DUT5(config-if)#isis srlg flex-algo 954
DUT5(config-if)#commit
DUT5(config-if)#
DUT5(config-if)#int ce2
% Warning: Executing the CLI from higher config mode level
DUT5(config-if)#
DUT5(config-if)#isis srlg flex-algo 955
DUT5(config-if)#isis srlg flex-algo 956
DUT5(config-if)#commit
DUT5(config-if)#
DUT5(config-if)#
DUT5(config-if)#
DUT5(config-if)#do sh isis int sa50
```

capability backup srlg-disjoint path

Use this command to enable TI-LFA SRLG disjoint backup path calculation for default algorithm.

Use the `no` parameter of this command to disable TI-LFA SRLG disjoint backup path calculation for default algorithm.

Command Syntax

```
capability backup srlg-disjoint path
[no] capability backup srlg-disjoint path
```

Parameters

None

Default

None

Command Mode

ISIS Config Mode

Applicability

Introduced in OcNOS version 7.0.0.

Example

```
ocnos(config)#router isis 1
ocnos(config-router)#flex-algo 128
```

show isis tilfa pq

Use this command to display the Topology-Independent Loop-Free Alternate (TI-LFA) PQ nodes. For a node with ECMP next-hops, this command displays P nodes, Q nodes and PQ nodes of each ECMP next-hop.

Command Syntax

```
show isis (WORD|) tilfa pq
```

Parameters

WORD

Information for a single ISIS area

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0. Enhanced the command for ECMP in OcNOS version 6.5.3.

Example

When the command is executed by specifying system-id parameter

```
#show isis tilfa pq 7010.00-00

Tag 100: Level-1 Link State Database:

Node: 7010.00-00
Interface xe5
  P node: 0000.0000.0010 primary dist:100
  P node: 0000.0000.0015 primary dist:150
  Q node: 0000.0000.0010
  Q node: 0000.0000.0015
  Node Protecting P Nodes
  P node: 0000.0000.0010 primary dist:100

  PQ Node: 7010.00-00 backup dist:100
  PQ Node (Node Protection): 7010.00-00 backup dist:100
Interface xe11
  P node: 0000.0000.0010 primary dist:100
  P node: 0000.0000.0015 primary dist:50
  Q node: 0000.0000.0010
  Q node: 0000.0000.0015
  Node Protecting P Nodes
  P node: 0000.0000.0015 primary dist:50

  PQ Node: 7015.00-00 backup dist:50
  No PQ Node found on backup path (Node Protection)
#
```

When the command is executed by specifying hostname parameter,
#show isis tilfa pq 7010

```
Tag 100: Level-1 Link State Database:

Node: 7010.00-00
Interface xe5
  P node: 0000.0000.0010 primary dist:100
  P node: 0000.0000.0015 primary dist:150
  Q node: 0000.0000.0010
  Q node: 0000.0000.0015
  Node Protecting P Nodes
  P node: 0000.0000.0010 primary dist:100
```

```

PQ Node: 7010.00-00 backup dist:100
PQ Node (Node Protection): 7010.00-00 backup dist:100
Interface xell
P node: 0000.0000.0010 primary dist:100
P node: 0000.0000.0015 primary dist:50
Q node: 0000.0000.0010
Q node: 0000.0000.0015
Node Protecting P Nodes
P node: 0000.0000.0015 primary dist:50

PQ Node: 7015.00-00 backup dist:50
No PQ Node found on backup path (Node Protection)
#

```

show ip ospf segment-routing capability

Use this command to display the segment routing capabilities of OSPF advertisement routers.

Command Syntax

```
show ip ospf (<0-65535>|) segment-routing capability
```

Parameters

<0-65535>

Router process identifier

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```

#sh ip ospf segment-routing capability
-----
Advertisement Router Capability :13.13.13.1
Algorithm                      :0
Total SID'S Supported          :8000
SID Range List Count          :1
SID's Range                    :16000 - 1048575
-----
Advertisement Router Capability :14.14.14.1
Algorithm                      :0
Total SID'S Supported          :8000
SID Range List Count          :1
SID's Range                    :16000 - 1048575
-----

```

show ip ospf segment-routing mapping-table

Use this command to display active/inactive segment routing prefix-to-SID mapping entries. After conflict resolution mapping entries area added to either active or inactive list.

Syntax

```
show ip ospf (<0-65535>|) segment-routing mapping-table (active| inactive|) (detail|)
```

Parameters

<0-65535>

Router process identifier

active

Active entries after conflict resolution

inactive

Inactive entries after conflict resolution

detail

Details

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show ip ospf segment-routing mapping-table active
OSPF process ID: 0
Conflict Resolution Policy: Quarantine

Prefix          SID Index      Range      Flags
5.5.5.5/32      555            1

Number of mapping entries in Active Table: 1

#show ip ospf segment-routing mapping-table inactive detail
OSPF process ID: 0
Conflict Resolution Policy: Quarantine

Prefix
5.5.5.5/32
  SID Index:      666
  Range:          1
  Last Prefix:    5.5.5.5/32
  Last SID Index: 666
  Binding Flags:
  SRMS pref:      128
  Status:         INACTIVE
  Advertising Router: 7.7.7.7
  Prefix Flags:   32

Number of mapping entries in Inactive Table: 1
```

show ip ospf segment-routing state

Use this command to display segment routing state details.

Command Syntax

```
show ip ospf (<0-65535>|) segment-routing state
```

Parameters

<0-65535>

Router process identifier

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show ip ospf 123 segment-routing state

OSPF process 123 Segment-Routing:
SR State: SR_ENABLED
SRGB Start: 17000,   SRGB Range: 18000
Operational state: enabled
```

show ip ospf tilfa-backup-path

Use this command to display the Topology-Independent Loop-Free Alternate (TI-LFA) post convergence path. For a node with ECMP next-hops, this command displays P nodes, Q nodes and PQ nodes.

Command Syntax

```
show ip ospf tilfa-backup-path
show ip ospf tilfa-backup-path
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 4.0. Enhanced the command for ECMP in OcNOS version 6.5.3.

Example

```
#show ip ospf tilfa-backup-path
```



```

OSPF process 100:
Route [10.10.10.10]
  Primary Path Nexthop   : 2.10.1.10, xe11
  PQ-node: 15.15.15.15
  Primary Path Nexthop   : 2.15.1.15, xe5
  PQ-node: 10.10.10.10
Route [15.15.15.15]
  Primary Path Nexthop   : 2.15.1.15, xe5
  PQ-node: 10.10.10.10
Neighbor [10.10.10.10]
  PQ-node: 15.15.15.15
Neighbor [15.15.15.15]
  PQ-node: 10.10.10.10

Displaying vertex-info in tilfa_network table
Vertex [2.2.2.2]

Vertex [10.10.10.10]
  Interface: xe11
    P node: 10.10.10.10 dist: 100
    P node: 15.15.15.15 dist: 50
    Q node: 10.10.10.10
    Q node: 15.15.15.15
    PQ-node: 15.15.15.15
    Backup out-interface: xe5
  Interface: xe5
    P node: 15.15.15.15 dist: 50
    P node: 10.10.10.10 dist: 100
    Q node: 10.10.10.10
    Q node: 15.15.15.15
    PQ-node: 10.10.10.10
    Backup out-interface: xe11

Vertex [15.15.15.15]
  Interface: xe5
    P node: 15.15.15.15 dist: 50
    P node: 10.10.10.10 dist: 100
    Q node: 10.10.10.10
    Q node: 15.15.15.15
    PQ-node: 10.10.10.10
    Backup out-interface: xe11

#

```

show ip ospf tilfa-repair-list

Use this command to display the Topology-Independent Loop-Free Alternate (TI-LFA) repair list. For an OSPFv2 IPv4 prefix with ECMP next-hops, this command displays the MPLS information.

Command Syntax

```
show ip ospf tilfa-repair-list
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 4.0. Enhanced this command for ECMP in OcNOS version 6.5.3.

Example

```
#show ip ospf tilfa-repair-list

2.2.2.2/32
  Primary Path Metric    :1
2.10.1.0/24
  Primary Path Metric    :100
2.15.1.0/24
  Primary Path Metric    :50
10.10.10.10/32
  Primary Path Metric    :101
  Route ftnix:5 ilmix:8
  SR Incoming Label      : 19010
  Primary Path Nexthop    : 2.10.1.10, xe11
  SR outgoing Label      : 19010
  PQ-node: 15.15.15.15
  Backup outgoing Label   : 19010
  Bypass_trunk id :101
  Backup out interface: xe5
  Primary Path Nexthop    : 2.15.1.15, xe5
  SR outgoing Label      : 19010
  PQ-node: 10.10.10.10
  Backup outgoing Label   : 3
  Bypass_trunk id :102
  Backup out interface: xe11

  Bypass-Trunk: 102 Name: 10.10.10.10_nexthop__10011 ftn_ix:8
  ftn_info->trunk_ftn_ix  : 8, ref_cnt : 3
  Number Of outgoing label: 1
  Outgoing labels:
    label 1: 19010
  Nexthop address: 2.10.1.10

10.15.1.0/24
  Primary Path Metric    :100
15.15.15.15/32
  Primary Path Metric    :51
  Route ftnix:6 ilmix:10
  SR Incoming Label      : 19015
  Primary Path Nexthop    : 2.15.1.15, xe5
  SR outgoing Label      : 19015
  PQ-node: 10.10.10.10
  Backup outgoing Label   : 19015
  Bypass_trunk id :102
  Backup out interface: xe11

  Bypass-Trunk: 101 Name: 15.15.15.15_nexthop__10005 ftn_ix:7
  ftn_info->trunk_ftn_ix  : 7, ref_cnt : 2
  Number Of outgoing label: 1
  Outgoing labels:
    label 1: 19015
  Nexthop address: 2.15.1.15

#
```

show isis segment-routing capability

Use this command to display the segment routing capabilities of ISIS advertisement routers.

Command Syntax

```
show isis (WORD|) segment-routing capability
```

Parameters

WORD

Routing area tag

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#sh isis segment-routing capability
-----
Advertisement Router Capability :13.13.13.1
Algorithm                     :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 1048575
-----
Advertisement Router Capability :14.14.14.1
Algorithm                     :0
Total SID'S Supported         :8000
SID Range List Count          :1
SID's Range                   :16000 - 1048575
-----
```

show isis segment-routing mapping-table

Use this command to display active/inactive segment routing prefix-to-SID mapping entries.

Command Syntax

```
show isis (WORD|) segment-routing mapping-table ipv4 (active| inactive) (detail|)
```

Parameters

WORD

Routing area tag

active

Active entries after conflict resolution

inactive

Inactive entries after conflict resolution

detail

Details

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show isis segment-routing mapping-table ipv4 active
Tag 1 Segment-Routing:
Conflict Resolution Policy: Quarantine

Prefix                SID Index    Range    Flags
10.0.12.0/24          21           1
30.0.14.0/31          22           1
1.1.1.1/32            10           1
Number of mapping entries in Active IPv4 Table: 3
```

show isis segment-routing state

Use this command to display the segment routing state.

Command Syntax

```
show isis (WORD|) segment-routing state
```

Parameters

WORD

Routing area tag

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show isis segment-routing state
Tag 1 Segment-Routing:
SR State: SR_ENABLED
SRGB Start: 16000, SRGB Range: 3001
Operational state: enabled
```

show mpls counters isis-segment-routing

Use this command to display traffic statistics for isis-segment-routing FTNs and ILMs.

Command Syntax

```
show mpls counters isis-segment-routing (ftn (A.B.C.D/M|)) | (ilm (A.B.C.D/M|))
```

Parameters

isis-segment-routing
isis segment-routing ftn's/ilm statistics

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

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.1.

**Note:** For Qumran, counters are not available for transit nodes.

Example

```
#show mpls counters isis-segment-routing ftn 3.3.3.3/32
+-----+-----+-----+-----+
|      FEC      | out-label | Tx packets | Tx bytes |
+-----+-----+-----+-----+
| 3.3.3.3/32    | 16004     | 7270160   | 58161640 |
+-----+-----+-----+-----+

#show mpls counters isis-segment-routing ilm 3.3.3.3/32
+-----+-----+-----+-----+-----+-----+
|      FEC      | in-label | out-label | Rx packets | Rx bytes | Tx
| packets      | Tx bytes |           |            |          |
+-----+-----+-----+-----+-----+-----+
| 3.3.3.3/32    | 16004    | 16004     | 0           | 0         | 0
|              | 0        |           |            |          |
+-----+-----+-----+-----+-----+-----+
#
```

[Table 8](#) explains the show command output fields.

Table 8. show mpls counters isis-segment-routing

Field	Description
FTN statistics	Displays the statistics details of FTN.

Field	Description
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 SR labeled(SID) packets received from the neighbor.
Rx bytes	Size SR labeled(SID) packets received from the neighbor.
Tx packets	Number of SR labeled(SID) labeled packets sent to the neighbor.
Tx bytes	Size of SR labeled(SID) packets sent to the neighbor.

```
show mpls counters ospf-segment-routing
```

Use this command to display traffic statistics for ospf-segment-routing FTNs and ILMs.

Command Syntax

```
show mpls counters ospf-segment-routing (ftn (A.B.C.D/M|)) | (ilm (A.B.C.D/M|))
```

Parameters

ospf-segment-routing

ospf segment-routing ftn's/ilm statistics

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

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.1.



Note: For Qumran, counters are not available for transit nodes.

Example

```
#show mpls counters ospf-segment-routing ftn 3.3.3.3/32
```

```

|          FEC          | out-label | Tx packets | Tx bytes |
+-----+-----+-----+-----+
| 3.3.3.3/32           | 16004     | 7270160   | 58161640 |
+-----+-----+-----+-----+

#show mpls counters ospf-segment-routing ilm 3.3.3.3/32
+-----+-----+-----+-----+-----+-----+
|          FEC          | in-label | out-label | Rx packets | Rx bytes | Tx
| packets              | Tx bytes |           |            |          |
+-----+-----+-----+-----+-----+-----+
| 3.3.3.3/32           | 16004    | 16004     | 0          | 0        | 0
| 0                    |          |           |            |          |
+-----+-----+-----+-----+-----+-----+

#
Table 1

```

[Table 9](#) explains the show command output fields.

Table 9. show mpls counters ospf-segment-routing

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 SR labeled(SID) packets received from the neighbor.
Rx bytes	Size SR labeled(SID) packets received from the neighbor.
Tx packets	Number of SR labeled(SID) labeled packets sent to the neighbor.
Tx bytes	Size of SR labeled(SID) packets sent to the neighbor.

show mpls counters sr-policy

Use this command to display traffic statistics for Segment Routing Policies.

Command Syntax

```
show mpls counters sr-policy ((policy-name NAME) |)
```

Parameters

policy-name

segment-routing policy name

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.1.



Note: For Qumran, counters are not available for transit nodes.

Example

```
#show mpls counters sr-policy policy-name p1 policy-name : p1 Tunnel-ID : 1 Rx pkts : 0 Rx bytes : 0
Tx pkts : 7270160 Tx bytes : 581614640 #show mpls counters sr-policy policy-name : p1 Tunnel-ID : 1
Rx pkts : 0 Rx bytes : 0 Tx pkts : 9610670 Tx bytes : 768855600
```

[Table 10](#) explains the show command output fields.

Table 10. show mpls counters sr-policy output field

Field	Description
policy-name	Segment-routing policy name.
Rx packets	Number of SR labeled(SID) packets received from the neighbor.
Rx bytes	Size of sr labeled packets(SID) received from the neighbor.
Tx packets	Number of SR labeled(SID) packets sent to the neighbor.
Tx bytes	Size of SR labeled(SID) packets sent to the neighbor.

trace mpls

Use this command to isolate the failure point of an LSP. It is used for hop-by-hop fault localization and path tracing. The MPLS LSP traceroute feature depends on the expiration of the packet's Time to Live (TTL) value that carries the echo request.

Users can initiate a Segment Routing traceroute operation only when the Segment Routing control plane is available at the origin. Use this command to verify connectivity when an LSP traverses entirely through a Segment Routing domain.

Command Syntax

```
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)|flags | destination A.B.C.D | source A.B.C.D | ttl <1-255> | timeout <1-500> | detail|})
```

Parameters

ospf-sr

Specifies the OSPF Segment Routing protocol domain.

isis-sr

Specifies the IS-IS Segment Routing protocol domain.

ipv4 A.B.C.D/M

Specifies the IPv4 prefix (FEC) of the LSP to trace.

sr-policy SR_POLICY_NAME

Specifies the Segment Routing Policy name for which the LSP traceroute is initiated.

candidate-path CANDIDATE_PATH_ID

Specifies the dynamic candidate path in the SR policy with the given candidate path ID.

reply-mode (2)

Defines the MPLS echo reply format. 2 - Reply via UDP or IP packet (default mode).

flags

Validate FEC stack.

destination A.B.C.D

Sets the destination IPv4 address used in the echo request packet.

source A.B.C.D

Sets the source IPv4 address used in the echo request packet.

ttl <1-255>

Specifies the Time To Live (TTL) value for the probe packet. Controls how many hops the trace explores. The range is 1–255. The default TTL is 255.

timeout <1-500>

Specifies the time to wait before declaring a probe as failed, in seconds. The range is 1–500. The default timeout is 60 seconds.

detail

Displays detailed output for the trace probe.

Default

None

Command Mode

Privileged Exec mode

Applicability

- Introduced in OcNOS Version SP 4.0.
- Removed repeat, interval, and force-explicit-null parameters in OcNOS version 6.6.1.

Examples

The following example shows how to trace an MPLS Label Switched Path (LSP) within an OSPF Segment Routing domain to verify hop-by-hop connectivity and identify the point of failure.

```
#trace mpls ospf-sr ipv4 10.0.1.33/32 destination 127.1.0.1 source 10.0.1.11 detail
Tracing MPLS Label Switched Path to 2.32.0.0, 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

```
0 10.11.1.1 [Labels: 16500]
R 1 10.0.1.1 [Labels: 16500] 0.97 ms
! 2 10.0.1.33 3.90 ms
```

```
# 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
```

trace mpls generic

Use this command to isolate the failure point of an LSP. It is used for hop-by-hop fault localization and path tracing. The MPLS LSP traceroute feature depends on the expiration of the packet's Time to Live (TTL) value that carries the echo request.

Use this command when an LSP traverses across multiple domains, such as segment routing and LDP domains, in the case of an SR-LDP interoperability scenario.

Command Syntax

```
trace mpls generic (ipv4 A.B.C.D/M) ({reply-mode 2 | flags | destination A.B.C.D | source A.B.C.D |  
ttl <1-255> | timeout <1-500> | detail})
```

Parameters

ipv4 A.B.C.D/M

Specifies the IPv4 prefix (FEC) of the LSP to trace.

reply-mode (2)

Defines the MPLS echo reply format. 2 - Reply via UDP or IP packet (default mode).

flags

Enables verification of the label stack and FEC validation in the reply.

destination A.B.C.D

Sets the destination IPv4 address used in the echo request packet.

source A.B.C.D

Sets the source IPv4 address used in the echo request packet.

ttl <1-255>

Specifies the Time To Live (TTL) value for the probe packet. Controls how many hops the trace explores. The range is 1–255. The default TTL is 255.

timeout <1-500>

Specifies the time to wait before declaring a probe as failed, in seconds. The range is 1–500. The default timeout is 60 seconds.

detail

Displays detailed output for the trace probe.

Default

None

Command Mode

Privileged Exec mode

Applicability

Introduced in OcNOS version 6.0.1.

Examples

```
#trace mpls generic ipv4 10.0.1.33/32 destination 127.1.0.1 source 10.0.1.11 detail
Tracing MPLS Label Switched Path to 2.32.0.0, 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

```
0 10.11.1.1 [Labels: 16500]
R 1 10.0.1.1 [Labels: 16500] 0.97 ms
! 2 10.0.1.33 3.90 ms
```

Segment Routing Mapping Server Commands

This section describes each segment routing mapping server command.

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

<1-4294967295>

Color value

Command Mode

Tunnel policy mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#tunnel-policy policy1
(config-tnl-policy)#color 2
```

```
(config)#tunnel-policy policy1
(config-tnl-policy)#no color 2
```

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.

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 5.1.

Example

```
#configure terminal
(config)#tunnel-policy policy1

#configure terminal
(config)#no tunnel-policy policy1
```

tunnel-select-policy

Use this command to set tunnel-policy for a VRF 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

VRF mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#ip vrf vrf1
(config-vrf)#tunnel-select-policy p1
(config-vrf)#commit
(config-vrf)#
(config)#ip vrf vrf1
(config-vrf)#no tunnel-select-policy
(config-vrf)#commit
(config-vrf)#
```

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

Defaults

NA

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#show running-config tunnel-policy
!
tunnel-policy tp
  color1
!
```

Segment Routing Policy Commands

This section describes the segment routing policy commands:

A.B.C.D (IP constraints)

Use this command to set IP constraints for a dynamic candidate path. Use the `no` form of this command to remove an IP constraint from a dynamic candidate path.

Command Syntax

```
A.B.C.D (loose|strict|)  
no A.B.C.D
```

Parameters

loose

Make this constraint loose

strict

Make this constraint strict

Default

By default, IP constraint is considered as loose.

Command Mode

ODN Candidate path constraint mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS#conf t  
OcNOS(config)#segment-routing  
OcNOS(config-sr)#traffic-engineering  
OcNOS(config-sr-te)#on-demand-nexthop 101  
OcNOS(config-sr-odn)#candidate-path 1  
OcNOS(config-sr-odn-cp)#constraints  
OcNOS(config-sr-odn-dyn-cp-cons)#1.1.1.1 loose  
OcNOS(config-sr-odn-dyn-cp-cons)#end
```

admin-state down

Use this command to bring down a segment routing policy administratively.

Use the `no` form of this command to bring up a segment routing policy administratively.

Command Syntax

```
admin-state down
no admin-state down
```

Parameters

None

Default

By default, admin-state is not configured and a segment routing policy admin-state is up.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#admin-state down
(config-sr-pol)#
```

affinity

Use this command to set a set affinity constraints for a dynamic candidate path.

Use the `no` form of this command to remove affinity constraints from a dynamic candidate path.

Command Syntax

```
affinity (exclude-any|include-all|include-any) ADMIN-GROUP-NAME
no affinity (exclude-any|include-all|include-any) ADMIN-GROUP-NAME
```

Parameters

exclude-any

Exclude any attribute

include-all

Include all attribute

include-any

Include any attribute

ADMIN-GROUP-NAME

Administrative group name

Default

By default, no affinity constraint is configured.

Command Mode

Candidate path constraint mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#dynamic-path isis
(config-sr-pol-cp)#constraints
(config-sr-pol-cp-cons)#affinity include-any red
(config-sr-pol-cp-cons)#
```

binding-sid mpls label

Use this command to configure binding SID MPLS label value for a segment routing policy.

Use the `no` form of this command to remove a binding SID.

Command Syntax

```
binding-sid mpls label <16-15999>
no binding-sid mpls label
```

Parameters

<16-15999>

MPLS Label

Default

By default, binding SID is not configured.

Command Mode

RSVP trunk mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#binding-sid mpls label 15000
(config-sr-pol)#

#configure terminal
(config)#rsvp-trunk mytrunk ipv4
(config-trunk)#binding-sid mpls label 15000
```

candidate-path

Use this command to configure a candidate path for a segment routing policy.

Use the `no` form of this command to remove a candidate path from a segment routing policy.

Command Syntax

```
candidate-path <1-65535>
no candidate-path <1-65535>
```

Parameters

<1-65535>

Identifier for candidate path

Default

By default, no candidate path is configured.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#
```

color end-point

Use this command to configure key parameters for segment routing policy.

Use the `no` form of this command to remove a segment routing policy key.

Command Syntax

```
color <1-4294967295> end-point A.B.C.D  
no color <1-4294967295> end-point A.B.C.D
```

Parameters

<1-4294967295>

Color value

A.B.C.D

IPv4 address type

Default

By default, no segment routing policy key is configured.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#segment-routing  
(config-sr)#traffic-engineering  
(config-sr-te)#policy SR_POLICY_1  
(config-sr-pol)#color 1 end-point 3.3.3.3  
(config-sr-pol)#
```

constraints

Use this command to set constraints for a dynamic candidate path.

Use the `no` form of this command to remove constraints from a dynamic candidate path.



Note: Constraints are not supported for explicit candidate path.

Command Syntax

```
constraints  
no constraints
```

Parameters

NA

Default

By default, constraints is not configured.

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#dynamic-path isis
(config-sr-pol-cp)#constraints
(config-sr-pol-cp-cons)#
```

cspf-retry-interval

Use this command to set the retry interval for two successive ISIS/OSPF CSPF computation for a candidate path.

Use the `no` form of this command to remove the CSPF retry interval.

Command Syntax

```
cspf-retry-interval <1-600>
no cspf-retry-interval
```

Parameters

<1-600>

Time in seconds between successive retries

Default

By default, the retry interval is 10 seconds.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#cspf-retry-interval 30
(config-sr-pol)#
```

cspf-retry-limit

Use this command to set the number of retries for ISIS/OSPF CSPF computation for a candidate path.

Use the `no` form of this command to set the CSPF retry limit to its default (100).



Note: CSPF computation engine will compute cspf for a requested path after each retry interval until this limit is reached.

Command Syntax

```
cspf-retry-limit <1-65535>
no cspf-retry-limit
```

Parameters

<1-65535>

Number of times CSPF should retry

Default

By default, the retry limit is 100.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#cspf-retry-limit 30
(config-sr-pol)#
```

debug sr-policy

Use this command to enable debugging for segment routing policy.

Use the `no` form of this command to disable debugging for segment routing policy.

Command Syntax

```
debug sr-policy all
no debug sr-policy all

debug sr-policy policy
no debug sr-policy policy
```

```
debug sr-policy cp
no debug sr-policy cp

debug sr-policy pce
no debug sr-policy pce
```

Parameters

all

Enable all debugging

policy

Enable policy debugging

cp

Enable candidate-path debugging

pce

Enable PCE debugging

Default

N/A

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#debug sr-policy pce
```

dynamic-path

Use this command to set a candidate path as a dynamic path and request the computation engine to compute LSP.

Use the `no` form of this command to remove a dynamic path type and computation engine from a candidate path.

Note: Candidate path type or computation engine cannot be updated.

Command Syntax

```
dynamic-path (isis (WORD|) | ospf (<0-65535>|) | pcep)
no dynamic-path (isis (WORD|) | (ospf <0-65535>|) | pcep)
```

Parameters

isis

Request ISIS

WORD

ISIS instance name

ospf

Request OSPF

<0-65535>

OSPF process identifier

pcep

Request PCEP

Default

By default, path type is not set and no computation engine is attached.

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#dynamic-path isis
(config-sr-pol-cp)#exit-pol-cp
(config-sr-pol)#candidate-path 2
(config-sr-pol-cp)#dynamic-path ospf
(config-sr-pol-cp)#
```

exit-cp-cons

Use this command to exit constraints mode and return to CP mode.

Command Syntax

```
exit-cp-cons
```

Parameters

None

Default

NA

Command Mode

Constrains mode

Applicability

This command was introduced in OcNOS version 6.6.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#constraints
(config-sr-dyn-cp-cons)#exit-cp-cons
(config-sr-pol-cp)#
```

exit-pol-cp

Use this command to go to policy mode from constraints mode.

Command Syntax

```
exit-pol-cp
```

Parameters

None

Default

NA

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#exit-pol-cp
(config-sr-pol)#
```

exit-sr-pol

Use this command to leave segment routing policy mode.

Command Syntax

```
exit-sr-pol
```

Parameters

NA

Default

NA

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#exit-pol-cp
(config-sr-pol)#exit-sr-pol
(config-sr-te)#
```

exit-sr-sl

Use this command to leave segment-list mode.

Command Syntax

```
exit-sr-sl
```

Parameters

None

Default

NA

Command Mode

Segment list mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list sid_list1
(config-sr-sl)#exit-sr-sl
(config-sr-te)#
```

exit-te

Use this command to leave traffic-engineering mode.

Command Syntax

```
exit-te
```

Parameters

None

Default

NA

Command Mode

Traffic engineering mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#exit-te
(config-sr)#
```

explicit segment-list

Use this command to configure a candidate path as an explicit path and attach a segment-list to it.

Use the no parameter of this command to remove explicit an segment-list from a candidate path.



Note: Only one segment-list can be attached to a candidate path.

Command Syntax

```
explicit segment-list WORD
no explicit segment-list WORD
```

Parameters

WORD

Name of the SID list

Defaults

By default, path type is not set and no segment-list is attached. Example updated in OcNOS version 6.6.1.

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal (config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list s1
(config-sr-sl)#commit
(config-sr-sl)#exit

(config)#
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_Policy_!
(config-sr-pol)#commit
(config-sr-pol)#color 1 end-point 2001::2
(config-sr-pol)#commit
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#commit
(config-sr-pol-cp)#explicit segment-list s1
(config-sr-pol-cp)#commit
```

explicit-null ipv4

Use this command to configure the explicit-null ipv4 label for a segment routing policy. This command adds the explicit null label at the bottom of the segment routing policy label stack.

Use the `no` form of this command to remove the explicit null label.

Command Syntax

```
explicit-null ipv4
no explicit-null ipv4
```

Parameters

None

Default

By default, the explicit null is disabled.

Command Mode

Segment routing policy mode.

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#explicit-null ipv4
(config-sr-pol)#
```

hop-limit

Use this command to set hop-limit constraint for a dynamic candidate path.

Use the **no** form of this command to remove hop-limit constraint from a dynamic candidate path.

Command Syntax

```
hop-limit <1-32>  
no hop-limit
```

Parameters

<1-32>

Specifies the number of acceptable hops.

Default

Not Configured

Command Mode

Candidate path constraint mode

Applicability

Introduced in OcNOS version 7.0.0

Example

```
#configure terminal  
(config)#segment-routing  
(config-sr)#traffic-engineering  
(config-sr-te)#policy p1  
(config-sr-pol)#candidate-path 1  
(config-sr-pol-cp)#dynamic-path isis 100  
(config-sr-pol-cp)#constraints  
(config-sr-dyn-cp-cons)#hop-limit 4
```

index segment-type-1

Use this command to configure a segment of explicit segment list.

Use the **no** form of this command to remove the corresponding segment list.

Command Syntax

```
index <1-65535> segment-type-1 <0-1048575>  
no index <1-65535> segment-type-1
```

Parameters

<1-65535>

Index number

<0-1048575>

Label value

Default

By default, no segment is configured.

Command Mode

Segment list mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list sid_list1
(config-sr-sl)#index 1 segment-type-1 16002
(config-sr-sl)#index 2 segment-type-1 16003
(config-sr-sl)#
```

metric-type

Use this command to set a metric-type for optimization objective.

Use the `no` form of this command to remove a metric type from a dynamic candidate path.

Command Syntax

```
metric-type (igp|te) (bound <1-4294967295>|)
no metric-type (igp|te)
```

Parameters**igp**

IGP metric

te

TE metric

bound

Maximum allowed metric for computed path

<1-4294967295>

Maximum allowed metric value

Default

By default, no metric and bound is configured.

Command Mode

Candidate path constraint mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#dynamic-path isis
(config-sr-pol-cp)#constraints
(config-sr-pol-cp-cons)#metric-type te
(config-sr-pol-cp-cons)#
```

ping mpls sr-policy

Use this command to check the connectivity between ingress and egress of LSP. This command uses MPLS echo request and reply messages, similar to Internet Control Message Protocol (ICMP) echo request and reply messages, to validate an LSP.

Segment routing ping is an extension of the MPLS LSP ping to perform connectivity verification on the segment routing control plane.

You can initiate the segment routing ping operation only when the segment routing control plane is available at the originator.

Command Syntax

```
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}||)
```

Parameters

local

Locally originated candidate path

pce

PCE originated candidate path

SR_POLICY_NAME

Segment routing policy name

CANDIDATE_PATH_ID

Candidate path identifier

flags

Validate FEC stack

source

Source address

A.B.C.D

IPv4 address of the source

ttl

Trace packet Time-to-live

<1-255>

Trace packet TTL value

timeout

Time to wait before rejecting the probe as a failure

<1-500>

Timeout in seconds

repeat

Repeat sending of ping packets

<5-5000>

Number of pings to send

interval

Interval between ping packets

<2-20000>

Interval in milliseconds

force-explicit-null

Force Explicit Null label

detail

Print detailed output of the ping

Defaults

Default TTL is 255.

Default timeout is 60 seconds.

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#ping mpls protocol-origin pcep sr-policy SR_POLICY_1 candidate-path 1
```

policy

Use this command to configure a segment routing policy.

Use the `no` form of this command to remove a segment routing policy.

Command Syntax

```
policy WORD  
no policy WORD
```


Parameters

WORD

Policy Name

Default

By default, no segment routing policy is configured.

Command Mode

Traffic engineering mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#
```

policy-fast-reroute-enable

Use this command to enable segment-routing policy fast-reroute for SR Policies.

Use the `no` form of this command to remove segment-routing policy fast-reroute for SR Policies.

Command Syntax

```
policy-fast-reroute-enable
no policy-fast-reroute-enable
```

Parameters

None

Default

By default, segment-routing policy fast-reroute is disabled.

Command Mode

Traffic engineering mode.

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy-fast-reroute-enable
(config-sr-te)#
```

preference

Use this command to set a preference value for a candidate path.

Use the `no` form of this command to remove a preference value from a candidate path.

Command Syntax

```
preference <1-65535>
no preference
```

Parameters

<1-65535>

Preference for candidate path

Default

By default, preference value is 100 for a candidate path.

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#preference 200
(config-sr-pol-cp)#
```

segment-list

Use this command to configure an explicit segment list.

Use the `no` form of this command to remove a segment list.

Command Syntax

```
segment-list WORD
no segment-list WORD
```

Parameters

WORD

Name of the SID list

Default

By default, no segment-list is configured.

Command Mode

Traffic engineering mode.

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list sid_list1
(config-sr-sl)#
```

show segment-routing policy

Use this command to display segment routing policy information.

Command Syntax

Use this command to display basic/detailed information for all SR policies:

```
show segment-routing policy (detail|)
```

Use this command to check details of a particular policy or a particular candidate path:

```
show segment-routing policy WORD (candidate-path <0-4294967295> origin (local|pce)|)
```

Use this command to check if a policy has candidate-paths with the given origin:

```
show segment-routing policy candidate-path origin (local|pce)
```

Parameters

detail

Display details of segment routing policies

WORD

Segment routing policy name

<0-4294967295>

Candidate-path identifier

local

Locally originated candidate path

pce

PCE originated candidate path

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show segment-routing policy detail
Policy-Name: 1      Color 1      End-point 18.18.18.18      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:01:14
State Transition Count: 3
CSPF Retry Limit: 100      CSPF Retry Interval: 10
Binding SID :
BSID: 26240
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 1, Active
Preference: 100      Path Type: Dynamic(isis)      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 3
Segment0[LABEL]: Label :26880
Segment1[LABEL]: Label :24961
Segment2[LABEL]: Label :24965
Out-if: po11      Out-label-stack: 3/24961/24965
Computed TE Metric: 30
Hop-Count: 3
Attributes:
Configured:
SID-Algorithm: 0
Affinity:
Metric-type: TE
IP Constraints:
Hop-Limit: 3

#show segment-routing policy p2

Policy-Name: p2      Color 1      End-point 3.3.3.3
Admin-Status: UP      Oper-Status: UP for 00:09:06
State Transition Count: 1
CSPF Retry Limit: 10      CSPF Retry Interval: 10
Binding SID :
BSID: 24960
Alloc mode: Dynamic
Oper State: Pending

CP ID: 2, Active
Preference: 100      Path Type: Dynamic(isis)      CP Origin: Local
Segment List:
Total no. of segments: 1
Segment0[LABEL]: Label :16033
```

```

    Out-if: eth1          Out-label-stack: 16033
    Attributes:
      Configured:
      Affinity:
      Metric-type: TE
      IP Constraints:

#show segment-routing policy candidate-path origin local

Policy-Name          Color      End-
point              State      Forwarding-Info
p2                  1          3.3.3.3          UP
  16033/eth1
  CP ID: 2, Active
  Preference: 100    Path Type: Dynamic(isis)    CP Origin: Local
  CP state: Valid
  Segment List:
  Total no. of segments: 1
    Segment0[LABEL]: Label :16033
  Out-if: eth1      Out-label-stack: 16033
  Attributes:
    Configured:
    Affinity:
    Metric-type: TE
    IP Constraints:

#show segment-routing policy

Policy-Name          Color      End-
point              State      Forwarding-Info
p2                  1          3.3.3.3          UP
  16033/eth1
#

#show segment-routin policy p2 candidate-path 2 origin local

Policy-Name: p2      Color 1      End-point 3.3.3.3
Admin-Status: UP      Oper-Status: UP
CP ID: 2, Active
Preference: 100    Path Type: Dynamic(isis)    CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 1
  Segment0[LABEL]: Label :16033
Out-if: eth1      Out-label-stack: 16033
Attributes:
  Configured:
  Affinity:
  Metric-type: TE
  IP Constraints:

```

traffic-engineering

Use this command to configure segment routing traffic engineering configuration.

Use the `no` form of this command to remove traffic engineering configuration.

Command Syntax

```

traffic-engineering
no traffic-engineering

```

Parameters

None

Default

By default, traffic-engineering is not configured.

Command Mode

Segment-routing mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#
```

Segment Routing v6 Commands

This section describes each segment routing command.

locators

Use this command to enter in to locators mode.

Use this no command to remove the locators configuration.

Command Syntax

```
locators
no locators
```

Parameters

None

Default

NA

Command Mode

SRv6 mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config-sr)#srv6
(config-srv6)#locators
(config-srv6-loc)#
```

```
(config-sr)#srv6
(config-srv6)#no locators
```

locator WORD

Use this command to configure locator name.

Use the no form of the command to remove the locator name.

Command Syntax

```
locators WORD
no locators WORD
```

Parameters

WORD

Locator name

Default

NA

Command Mode

Locators mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config-sr)#srv6
(config-srv6)#locators
(config-srv6-loc)#locator LOC_PE1
(config-srv6-loc-conf)#
```

```
(config-sr)#srv6
(config-srv6)#locators
(config-srv6-loc)#no locator LOC_PE1
```

prefix X:X::X:X/X

Use this command to configure locator prefix.

Use the no form of the command to unconfigure locator prefix

Command Syntax

```
prefix X:X::X:X/X  
no prefix
```

Parameters

X:X::X:X/X

Locator prefix (i.e IPv6 address)

Default

NA

Command Mode

Locator configure mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config)#segment-routing  
(config-sr)#srv6  
(config-srv6)#locators  
(config-srv6-loc)#locator LOC_PE1  
(config-srv6-loc-conf)#prefix 2981:40:a1::/64  
(config-srv6-loc-conf)#  
  
(config)#segment-routing  
(config-sr)#srv6  
(config-srv6)#locators  
(config-srv6-loc)#locator LOC_PE1  
(config-srv6-loc-conf)#no prefix
```

segment-routing srv6 (IPv4)

Use this command to enter into segment routing SRv6 mode

Use the no form of this to remove segment routing SRv6.

Command Syntax

```
segment-routing srv6
```

Parameters

None

Command Mode

IPv4 address family for VRF mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config)#router bgp 100
(config-router)#address-family ipv4 vrf vrf1
(config-router-af)#segment-routing srv6
(config-router-vrfv4-srv6)#

(config)#
(config)#router bgp 100
(config-router)#address-family ipv4 vrf vrf1
(config-router-af)#no segment-routing srv6
```

segment-routing srv6 (ISIS)

Use this command to enter segment routing SRv6 mode.

Use the no form of this command to unconfigure segment routing SRv6.

Command Syntax

```
segment-routing srv6
no segment-routing srv6
```

Parameters

None

Default

NA

Command Mode

Address Family IPv6 mode under router ISIS mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config)#router isis 1
(config-router)#address-family ipv6
(config-router-af)#segment-routing srv6
(config-router-af-srv6)#

(config)#router isis 1
(config-router)#address-family ipv6
(config-router-af)#no segment-routing srv6
```

segment-routing srv6 (OSPFv3)

Use this command to enter into segment routing SRv6 mode

Use the no form this to command to disable SRv6 for OSPFv3

Command Syntax

```
segment-routing srv6
no segment-routing srv6
```

Parameters

NA

Default

NA

Command Mode

Router IPv6 OSPF mode

Applicability

This command was introduced in OcNOS version 5.1

Example

```
R1#configure t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router ipv6 ospf 1
R1(config-router)#segment-routing srv6
R1(config-router-srv6)# exit-srv6

R1(config)#router ipv6 ospf 1
R1(config-router)#no segment-routing srv6
R1(config-router-srv6)# exit-srv6
```

segment-routing srv6 (VPNv4)

Use this command to enter into segment routing SRv6 mode

Command Syntax

```
segment-routing srv6
```

Parameters

None

Command Mode

VPNv4 address family mode

Applicability

This command was introduced before OcNOS version 5.1.

Example

```
(config)#router  bgp 100
(config-router)#address-family vpnv4 unicast
(config-router-af)#segment-routing srv6
(config-router-vpnv4-srv6)#

(config)#router  bgp 100
(config-router)#address-family vpnv4 unicast
(config-router-af)#no segment-routing srv6
```

srv6

Use this command to enter in to SRv6 mode.

Use this no command to remove the SRv6 configuration.

Command Syntax

```
srv6
no srv6
```

Parameters

None

Default

NA

Command Mode

segment-routing mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config)#segment-routing
(config-sr)#srv6
(config-srv6)#

(config)#segment-routing
(config-sr)#no srv6
```

srv6-locator

Use this command to configure SRv6 locator word.

Use the no form this to command to remove SRv6 locator word.

Command Syntax

```
srv6-locator WORD
```

Parameters

WORD

Name of the Locator List

Command Mode

Segment routing srv6 mode

Applicability

This command was introduced before OcNOS version 5.1.

Example

```
(config)#router  bgp 100
(config-router)#address-family vpnv4 unicast
(config-router-af)#segment-routing srv6
(config-router-vpnv4-srv6)#srv6-locator LOC_PE1
(config-router-vpnv4-srv6)#
```

srv6-locator WORD

Use this command to configure SRv6 locator name.

Use the no form to unconfigure the SRv6 locator name.

Command Syntax

```
srv6-locator WORD
no srv6-locator WORD
```

Parameters

WORD

Locator name

Default

NA

Command Mode

Segment routing SRv6 mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config)#router isis 1
(config-router)#address-family ipv6
(config-router-af)#segment-routing srv6
(config-router-af-srv6)#srv6-locator LOC_PE1

(config)#router isis 1
(config-router)#address-family ipv6
(config-router-af)#segment-routing srv6
(config-router-af-srv6)#no srv6-locator LOC_PE1
```

srv6-locator WORD (OSPFv3)

Use this command to configure SRv6 locator word.

Use the no form this to command to remove SRv6 locator word.

Command Syntax

```
srv6-locator WORD
no srv6-locator WORD
```

Parameters

WORD

Name of the Locator List

Default

None

Command Mode

Segment routing SRv6 mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
R1(config)#router ipv6 ospf 1
R1(config-router)#segment-routing srv6
R1(config-router-srv6)#srv6-locator L1
R1(config-router-srv6)# exit-srv6

R1(config)#router ipv6 ospf 1
R1(config-router)#segment-routing srv6
R1(config-router-srv6)#no srv6-locator L1
R1(config-router-srv6)# exit-srv6

R1#show running-config segment-routing
!
segment-routing
  srv6
    locators
```

```

locator L1
  prefix 2981:40:a1::/64
exit-locator
!
exit-locators
!
exit-srv6
!
!
R1#show running-config router ipv6 ospf
!
router ipv6 ospf 1
  router-id 1.1.1.1
  segment-routing srv6
    srv6-locator L1
  exit-srv6
!
!
R1#

R1#show segment-routing srv6 sid
SRv6 Segment ID table:
SID                               Operation  Nexthop                Originator
+-----+-----+-----+-----+
2981:40:a1:0:801::               END[usd]   ::                     nsm
2981:40:a1:0:1001::              END[usp]   ::                     nsm
2981:40:a1:0:2001::              END[psp]   ::                     nsm
2981:40:a1:0:2002::              END.X[psp] fe80::5054:ff:fe1f:b4e7 ospf

```

show ipv6 ospf database <LSA name>

Use this command to display segment routing v6 related LSA information.

Command Syntax

```
show ipv6 ospf database (opaque|locator|ext-router)
```

Parameters

opaque

locator

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```

R1#show ipv6 ospf database opaque

      OSPFv3 Router with ID (1.1.1.1) (Process 1)

      Opaque-LSA (Area 0.0.0.0)

      LS age: 752
      LS Type: Opaque RI LSA

```

```

Link State ID: 0.0.0.3
Advertising Router: 1.1.1.1
LS Seq Number: 0x8000002D
Checksum: 0xF685
Length: 48

Router Capability TLV:
Flags:0   Reserve bits:0

Algorithm TLV :
  Algorithm: 0

Maximum SID Depth :
  SRH maximum segments left (41) : 4
  SRH maximum end pop (42) : 4
  SRH maximum H.encaps (44) : 4
  SRH maximum decapsulation sids (45) : 4

```

```

LS age: 754
LS Type: Opaque RI LSA
Link State ID: 0.0.0.0
Advertising Router: 2.2.2.2
LS Seq Number: 0x8000070D
Checksum: 0x2272
Length: 48

```

```

Router Capability TLV:
Flags:0   Reserve bits:0

```

```

Algorithm TLV :
  Algorithm: 0

```

```

Maximum SID Depth :
  SRH maximum segments left (41) : 4
  SRH maximum end pop (42) : 4
  SRH maximum H.encaps (44) : 4
  SRH maximum decapsulation sids (45) : 4

```

```
R1#show ipv6 ospf database locator
```

```
    OSPFv3 Router with ID (1.1.1.1) (Process 1)
```

```
        Locator-LSA (Area 0.0.0.0)
```

```

LS age: 765
LS Type: Locator LSA
Link State ID: 0.0.0.3
Advertising Router: 1.1.1.1
LS Seq Number: 0x8000002D
Checksum: 0xD97A
Length: 120

```

```

Locator-TLV (Length:96):
  Route type:0   Algorithm:0
  Flags:0       Metric:0
  Prefix: 2981:40:a1::/64

```

```

SRv6 END Sub TLV (Length:20):
  Flags:0       Reserved:0
  END SID: 2981:40:a1:0:2001::
  End-point behaviour: End with PSP (2)

```

```

SRv6 END Sub TLV (Length:20):
  Flags:0       Reserved:0
  END SID: 2981:40:a1:0:1001::
  End-point behaviour: End with USP (3)

```

```
SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: 2981:40:a1:0:801::
  End-point behaviour: End with USD (28)
```

```
LS age: 767
LS Type: Locator LSA
Link State ID: 0.0.0.3
Advertising Router: 2.2.2.2
LS Seq Number: 0x8000070D
Checksum: 0x1697
Length: 120
```

```
Locator-TLV (Length:24):
  Route type:0      Algorithm:0
  Flags:0      Metric:0
  Prefix: 2981:40:a2::/64
```

```
SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: 2981:40:a2:0:2001::
  End-point behaviour: End with PSP (2)
```

```
SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: 2981:40:a2:0:1001::
  End-point behaviour: End with USP (3)
```

```
SRv6 END Sub TLV (Length:20):
  Flags:0      Reserved:0
  END SID: 2981:40:a2:0:801::
  End-point behaviour: End with USD (28)
```

```
R1#show ipv6 ospf database ext-router
```

```
OSPFv3 Router with ID (1.1.1.1) (Process 1)
```

```
Ext-Router-LSA (Area 0.0.0.0)
```

```
LS age: 774
LS Type: External-Router-LSA
Link State ID: 0.0.0.3
Advertising Router: 1.1.1.1
LS Seq Number: 0x8000002D
Checksum: 0x41A0
Length: 76
Flags: 0x00 (-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)
```

```
Router-Link TLV (Length:48): a Transit Network
  Metric: 1
  Interface ID: 3
  Neighbor Interface ID: 3
  Neighbor Router ID: 2.2.2.2
```

```
SRv6 LAN End.X SID Sub-TLV (Length: 28):
  Neighbor Router ID: 2.2.2.2
  SRV6 P2P END.X SID: 2981:40:a1:0:2002::
  Algo: 0 flags: 0
  End-behaviour: End.X with PSP (6) weight: 0
```

```
LS age: 776
LS Type: External-Router-LSA
Link State ID: 0.0.0.3
Advertising Router: 2.2.2.2
LS Seq Number: 0x8000070D
```



```
Checksum: 0x1CE2
Length: 76
Flags: 0x00 (-|-|-|-)
Options: 0x000133 (AF|*|*|DC|R|-|-|E|V6)

Router-Link TLV (Length:16): a Transit Network
Metric: 1
Interface ID: 3
Neighbor Interface ID: 3
Neighbor Router ID: 2.2.2.2

SRv6 LAN End.X SID Sub-TLV (Length: 28):
Neighbor Router ID: 1.1.1.1
SRV6 P2P END.X SID: 2981:40:a2:0:201d::
Algo: 0 flags: 0
End-behaviour: End.X with PSP (6) weight: 0
```

show segment-routing srv6 locator

Use this command to display segment routing v6 locator information.

Command Syntax

```
show segment-routing srv6 locator WORD (detail|)
```

Parameters

detail

Locator name

WORD

Display locator detail information

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
show segment-routing srv6 locator LOC_PE1
Locator : LOC_PE1
Prefix : 9999:9:a3::/48

show segment-routing srv6 locator LOC_PE1 detail
Locator : LOC_PE1
Prefix : 9999:9:a3::/48
Uptime : 01d00h31m
```

show segment-routing srv6 manager

Use this command to display segment routing v6 Manager information.

Command Syntax

```
show segment-routing srv6 manager
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
VPC3#sh segment-routing srv6 manager
Protocol state : Enabled
Locators:
PE1
Platform Capabilities:
End Function:
End (PSP)
End (USP)
End (USD)
End.X (PSP)
End.DT4
Ingress Functions:
H.Encaps
Ingress SR Policy:
H.Encaps
```

show segment-routing srv6 services

Use this command to display segment routing v6 service information.

Syntax

```
show segment-routing srv6 services
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
PE1#sh segment-routing srv6 services
Codes: > - installed; T:Uses service-mapped tunnel
Service Flags
vrf          FEC          SID          Nexthop          Tunnel ix
vpnv4 >      vrf2          2.6.7.0/24    9999:9:a7:0:8001:: 9999:9:7:1::
None
vpnv4 >      vrf2          2.7.11.0/24   9999:9:a7:0:8001:: 9999:9:7:1::
None
vpnv4 >      vrf3          2.7.77.0/24   9999:9:a7:0:8002:: 9999:9:7:1::
None
```

show segment-routing srv6 sid

Use this command to display segment routing v6 SID information.

Command Syntax

```
show segment-routing srv6 sid (id WORD|)
```

Parameters

WORD

Display SRv6 SID detail information (Segment ID string)

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
PE1#show segment-routing srv6 sid
SRv6 Segment ID table:
SID          Operation Nexthop          Originator
+-----+-----+-----+-----+
2981:40:a1:0:801::  END[usd]  ::          nsm
2981:40:a1:0:1001:: END[usp]  ::          nsm
2981:40:a1:0:2001:: END[psp]  ::          nsm
2981:40:a1:0:6001:: END.X      fe80::5054:ff:fe9c:bbad isis
2981:40:a1:0:8001:: END.DT4    vrf vrf2     bgp:100
2981:40:a1:0:8002:: END.DT4    vrf vrf3     bgp:100

PE1#show segment-routing srv6 sid id 2981:40:a1:0:6001::
SRv6 Segment ID table:
SID          Operation Nexthop          Originator
+-----+-----+-----+-----+
2981:40:a1:0:6001:: END.X      fe80::5054:ff:fe9c:bbad isis
```

show segment-routing srv6 transports

Use this command to display all SRv6 transport and their mapping to services using detail command.

Command Syntax

```
show segment-routing srv6 transports (X:X::X:X/M|detail|)
```

Parameters

detail

Display detail information's of SRv6 transports like services attached to them.

X:X::X:X/M

FEC IPv6

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
PE-135#show segment-routing srv6 transports 2001:12::2/128
Codes: > - installed P6, * - selected P6, p - stale P6,
       U - unknown P6
```

Code	FEC	SRv6-Policy-Name	color	Pri	Out-SID	Out-
Intf	Nexthop					
>	2001:12::2	p4	4	Y	2001::2	eth1 fe80::
	5054:ff:fe9c:bbad					
>	2001:12::2	p1	1	Y	2001::2	eth1 fe80:
	:5054:ff:fe9c:bbad					

```
PE-135#show segment-routing srv6 transports
Codes: > - installed P6, * - selected P6, p - stale P6,
       U - unknown P6
```

Code	FEC	SRv6-Policy-Name	color	Pri	Out-SID	Out-
Intf	Nexthop					
>	2001:12::2	p4	4	Y	2001::2	eth1 fe80::
	5054:ff:fe9c:bbad					
>	2001:12::2	p1	1	Y	2001::2	eth1 fe80:
	:5054:ff:fe9c:bbad					

```
PE-135#show segment-routing srv6 transports detail
Codes: > - installed P6, * - selected P6, p - stale P6,
       U - unknown P6
```

Code	FEC	SRv6-Policy-Name	color	Pri	Out-SID	Out-
Intf	Nexthop					
>	2001:12::2	p4	4	Y	2001::2	eth1 fe80::
	5054:ff:fe9c:bbad					
Service info						
VRF-ID :3 Prefix 90.1.1.0 NH :2001:12::2 Tnl_policy : p2 color:4						
>	2001:12::2	p1	1	Y	2001::2	eth1 fe80:
	:5054:ff:fe9c:bbad					
Service info						
VRF-ID :2 Prefix 80.1.1.0 NH :2001:12::2 Tnl_policy : p1 color:1						

sid-alloc per-vrf

Use this command to configure the SID allocation per VRF.

Use the no form of the command to remove the SID allocation per VRF.

Command Syntax

```
sid-alloc per-vrf
```

Parameters

None

Command Mode

Segment routing SRv6 mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
(config)#router bgp 100
(config-router)#address-family ipv4 vrf vrf1
(config-router-af)#segment-routing srv6
(config-router-vrfv4-srv6)#
(config-router-vrfv4-srv6)#sid-alloc per-vrf
(config-router-vrfv4-srv6)#

(config)#router bgp 100
(config-router)#address-family ipv4 vrf vrf1
(config-router-af)#segment-routing srv6
(config-router-vrfv4-srv6)#
(config-router-vrfv4-srv6)#no sid-alloc per-vrf
```

Segment Routing v6 Policy Commands

This section describes each segment routing command.

admin-state down

Use this command to bring down a segment routing policy administratively.

Use the no parameter of this command to bring up a segment routing policy administratively.

Command Syntax

```
admin-state down
no admin-state down
```

Parameters

None

Defaults

By default, admin-state is not configured and a segment routing policy admin-state is up.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#admin-state down
```

candidate-path

Use this command to configure a candidate path for a segment routing policy.

Use the no parameter of this command to remove a candidate path from a segment routing policy.

Command Syntax

```
candidate-path <1-65535>
no candidate-path <1-65535>
```

Parameters

<1-65535>

Identifier for candidate path

Default

By default, no candidate path is configured.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)

#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#no candidate-path 1
```

color end-point

Use this command to configure key parameters for segment routing policy.

Use the no parameter of this command to remove a segment routing policy key.

Command Syntax

```
color <1-4294967295> end-point X:X::X:X
no color <1-4294967295> end-point X:X::X:X
```

Parameters

<1-4294967295>

Color value

X:X::X:X

IPv6 address type

Defaults

By default, no segment routing policy key is configured.

Command Mode

Segment routing policy mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#color 1 end-point 2001::2
(config-sr-pol)

#configure terminal
(config)#segment-routing
```

```
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#no color 1 end-point 2001::2
```

explicit segment-list

Use this command to configure a candidate path as an explicit path and attach a segment-list to it.

Use the no parameter of this command to remove explicit an segment-list from a candidate path.



Note: Only one segment-list can be attached to a candidate path.

Command Syntax

```
explicit segment-list WORD
no explicit segment-list WORD
```

Parameters

WORD

Name of the SID list

Defaults

By default, path type is not set and no segment-list is attached. Example updated in OcNOS version 6.6.1.

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list s1
(config-sr-sl)#commit
(config-sr-sl)#exit

(config)#
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_Policy_!
(config-sr-pol)#commit
(config-sr-pol)#color 1 end-point 2001::2
(config-sr-pol)#commit
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#commit
(config-sr-pol-cp)#explicit segment-list s1
(config-sr-pol-cp)#commit
```

index segment-type-2

Use this command to configure a segment of explicit segment list.

Use the no parameter of this command to remove the corresponding segment list.

Command Syntax

```
index <1-65535> segment-type-2 X:X::X:X
no index <1-65535> segment-type-2
```

Parameters

<1-65535>

Index number.

X:X::X:X

IPv6 address.

Default

By default, no segment is configured.

Command Mode

Segment list mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list sid_list2
(config-sr-sl)#index 1 segment-type-2 cafe:1:2:a11:1001::

#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list sid_list2
(config-sr-sl)#no index 1 segment-type-2
```

policy

Use this command to configure a segment routing policy.

Use the no parameter of this command to remove a segment routing policy.

Command Syntax

```
policy WORD
no policy WORD
```

Parameters

WORD

Policy Name

Default

By default, no segment routing policy is configured.

Command Mode

Traffic engineering mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#

#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#no policy SR_POLICY_1
```

preference

Use this command to set a preference value for a candidate path.

Use the no parameter of this command to remove a preference value from a candidate path.

Command Syntax

```
preference <1-65535>
no preference
```

Parameters

<1-65535>

Preference for candidate path

Defaults

By default, preference value is 100 for a candidate path.

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 5.1. keyword “no-preference” value “200” removed to avoid configuration error in OcNOS version 6.6.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#preference 200
(config-sr-pol-cp)#

#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#policy SR_POLICY_1
(config-sr-pol)#candidate-path 1
(config-sr-pol-cp)#no preference (config-sr-pol-cp)#commit (config-sr-pol-cp)#
```

segment-list

Use this command to configure an explicit segment list.

Use the no parameter of this command to remove a segment list.

Command Syntax

```
segment-list WORD
no segment-list WORD
```

Parameters

WORD

Name of the SID list.

Default

By default, no segment-list is configured.

Command Mode

Traffic engineering mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#segment-list sid_list1
```

```
(config-sr-sl)#  
  
#configure terminal  
(config)#segment-routing  
(config-sr)#traffic-engineering  
(config-sr-te)#no segment-list sid_list1  
(config-sr-sl)#
```

show segment-routing policy

Use this command to display segment routing v6 policy information (display basic/detailed information for all SR policies).

Command Syntax

```
show segment-routing policy (detail|)
```

Parameters

None

Defaults

detail

Display details of segment routing policies

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
PE2# show segment-routing policy detail  
Policy-Name: p1      Color 1      End-point cafe:1:2::11      Tunnel-ID: 1  
Admin-Status: UP      Oper-Status: UP for 00:03:39  
State Transition Count: 3  
CP ID: 2, Active  
  Preference: 200      Path Type: Explicit      CP Origin: Local  
  CP state: Valid  
  Segment List:  
  Total no. of segments: 1  
  Segment0[LABEL]: Label :cafe:1:2:a11:1001::  
  Out-if: ce62      Out-label-stack: cafe:1:2:a11:1001::  
  Attributes:  
    Configured:  
      Explicit segment-list Name: l1  
  
CP ID: 1  
  Preference: 100      Path Type: Explicit      CP Origin: Local  
  CP state: Valid  
  Segment List:  
  Total no. of segments: 1  
  Segment0[LABEL]: Label :cafe:1:2:a11:1001::
```

```

Out-if: ce62          Out-label-stack: cafe:1:2:a11:1001::
Attributes:
  Configured:
    Explicit segment-list Name: l

```

```

PE2# sho segment-routing policy
Policy-Name          Color      End-
point               State      Forwarding-Info
p1                   1             cafe:1:2::11    UP
  cafe:1:2:a11:1001::/ce62

```

show running-config segment-routing

Use this command to show any segment routing related running configuration.

Command Syntax

```
show running-config segment-routing
```

Parameters

None

Command Mode

Privileged Exec mode

Applicability

This command was introduced before OcNOS version 5.1.

Example

```

#show running-config segment-routing
!
segment-routing
  srv6
    locators
      locator VPC12
        prefix 2981:40:a1::/48
      exit-locator
    !
  exit-locators
!
exit-srv6
!
traffic-engineering
  segment-list l1
    index 1 segment-type-2 2981:40:a2:0:1001::
    index 2 segment-type-2 2981:40:a2:0:3001::
  exit-sr-sl
!
  policy p1
    color 1 end-point 2001::2
    candidate-path 1

```

```
    explicit segment-list l1
  exit-pol-cp
  !
exit-sr-pol
!
policy p2
  color 2 end-point 2001::2
  candidate-path 2
    explicit segment-list l1
  exit-pol-cp
  !
exit-sr-pol
!
exit-te
!
```

traffic-engineering

Use this command to configure segment routing traffic engineering configuration.

Use the no form of this command to remove traffic engineering configuration.

Command Syntax

```
traffic-engineering
no traffic-engineering
```

Parameters

None

Default

By default, traffic-engineering is not configured.

Command Mode

Segment-routing mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#segment-routing
(config-sr)#traffic-engineering
(config-sr-te)#

#configure terminal
(config)#segment-routing
(config-sr)#no traffic-engineering
```

Segment Routing v6 OAM Commands

This section describes Segment Routing IPv6 Operations, Administration, and Maintenance (OAM) commands.

ping srv6

Use this command to check the connectivity between ingress and egress of LSP. This command uses Internet Control Message Protocol (ICMPv6) echo request and reply messages to validate an LSP.

Use this command to check connectivity if an LSP traverses entirely through an SRv6 domain.

You can initiate the segment routing of ipv6 ping operation only when the SRv6 control plane is available at the originator.

Command Syntax

```
ping srv6 (ipv6 X:X::X:X| sid SID) (via segment-list .SID_VALUE sid-list-end |) ({source-ip X:X::X:X  
|  
repeat <5-5000> |interval <2-20000>})
```

Parameters

ipv6

IPv6 Address

X:X::X:X

Ping SRv6 destination address

sid

Segment list ID

SID

Ping SID value

via segment-list

List of segments to pass through

SID_VALUE

SID value

sid-list-end

End of the segment list

source-ip

Source IPv6 address to use in ICMPv6 packet

X:X::X:X

Source IPv6 address in the ping

repeat

Repeat sending of ping packet

<5-5000>

Number of pings to send

interval

Interval between ping packets

<2-20000>

Interval between pings in milliseconds

Defaults

No defaults

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 6.3.0.

Example

```
PE1#ping srv6 ipv6 cafe:1:2::22
Sending 5 SRV6 Echos to cafe:1:2::22, timeout is 5 seconds
Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort
! seq_num = 1 :: 1.44 ms
! seq_num = 2 :: 0.68 ms
! seq_num = 3 :: 0.34 ms
! seq_num = 4 :: 0.51 ms
! seq_num = 5 :: 0.36 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.34/0.89/1.44
```

traceroute srv6

Use this command to isolate the failure point of an LSP. This command is used for hop-by-hop fault localization and path tracing.

You can initiate the SRv6 traceroute operation only when the SRv6 control plane is available at the originator.

Use this command to check connectivity if an LSP traverses entirely through segment routing for an SRv6 domain.

Command Syntax

```
traceroute srv6 (ipv6 X:X::X:X| sid SID) (via segment-list .SID_VALUE sid-list-end |) (source-ip X:X::X:X |)
```

Parameters

ipv6

IPv6 Address

X:X::X:X

Ping SRv6 destination address

sid

Segment list ID

SID

Ping SID value

via segment-list

List of segments to pass through

SID_VALUE

SID value

sid-list-end

End of the segment list

source-ip

Source IPv6 address to use in ICMPv6 packet

X:X::X:X

Source IPv6 address in the ping

Defaults

No defaults

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 6.3.0.

Example

```
PE1#traceroute srv6 ipv6 cafe:1:2::22 source-ip cafe:1:2::11
Traceroute to cafe:1:2::22 ( cafe:1:2::22), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort
1 1000::2 0.80 ms 0.46 ms 0.46 ms
DA: cafe:1:2::22
SRH:(cafe:1:2::22,SL = 0)
2 cafe:1:2::22 0.51 ms 0.56 ms 0.36 ms
DA: cafe:1:2::22
SRH:(cafe:1:2::22,SL = 0)
3 cafe:1:2::22 0.51 ms
```

ping srv6 policy

Use this command to check the connectivity between ingress and egress of LSP. This command uses Internet Control Message Protocol (ICMPv6) echo request and reply messages, to validate an LSP.

Use this command to check connectivity if an LSP traverses entirely through a SRv6 domain.

You can initiate the SRv6 policy ping operation only when the SRv6 control plane is available at the originator.

Command Syntax

```
ping srv6 (| protocol-origin (local | pcep) ) (policy SRV6_POLICY_NAME (| candidate-path CANDIDATE_PATH_ID)) ({source-ip X:X::X:X | repeat <5-5000> |interval <2-20000>})
```

Parameters

protocol-origin

Originator

local

Locally originated candidate path

pcep

PCE originated candidate path

policy

Segment Routing IPv6 policy

SRV6_POLICY_NAME

SRv6 Policy name

candidate-path

Candidate path

CANDIDATE_PATH_ID

Candidate path identifier

source-ip

Source IPv6 address to use in ICMPv6 packet

X:X::X:X

Source IPv6 address in the ping

repeat

Repeat sending of ping packet

<5-5000>

Number of pings to send

interval

Interval between ping packets

<2-20000>

Interval between pings in milliseconds

Defaults

No defaults

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 6.3.0.

Example

```
PE1#ping srv6 policy P1 candidate-path 1
Sending 5 SRV6 Echos to P1 , timeout is 5 seconds
Codes:
'!' - Success, 'Q' - request not sent, '*' - timeout,
'x' - Retcode 0, 'M' - Malformed Request
Type 'Ctrl+C' to abort
! seq_num = 1 :: 0.62 ms
! seq_num = 2 :: 0.52 ms
! seq_num = 3 :: 0.38 ms
! seq_num = 4 :: 0.50 ms
! seq_num = 5 :: 0.44 ms
Success Rate is 100.00 percent (5/5)
round-trip min/avg/max = 0.38/0.50/0.62
```

traceroute srv6 policy

Use this command to isolate the failure point of an LSP. This command is used for hop-by-hop fault localization and path tracing.

You can initiate the SRv6 policy traceroute operation only when the SRv6 control plane is available at the originator.

Use this command to check connectivity if an LSP traverses entirely through segment routing for an SRv6 domain.

Command Syntax

```
traceroute srv6 (| protocol-origin (local | pcep) ) (policy SRV6_POLICY_NAME (| candidate-path  
CANDIDATE_PATH_ID))  
(source-ip X:X::X:X|)
```

Parameters

protocol-origin

Originator

local

Locally originated candidate path

pcep

PCE-originated candidate path

policy

Segment Routing IPv6 policy

SRV6_POLICY_NAME

SRv6 Policy name

candidate-path

Candidate path

CANDIDATE_PATH_ID

Candidate path identifier

source-ip

Source IPv6 address to use in ICMPv6 packet

X:X::X:X

Source IPv6 address in the ping

repeat

Repeat sending of ping packet

<5-5000>

Number of pings to send

interval

Interval between ping packets

<2-20000>

Interval between pings in Milliseconds

Defaults

No defaults

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 6.3.0.

Example

```
PE1#traceroute srv6 protocol-origin local policy P1 candidate-path 1
Traceroute to P1 ( P1 ), 30 hops max, 80 byte packets
Type 'Ctrl+C' to abort
 1 1000::2 0.73 ms 0.50 ms 0.46 ms
DA: cafe:1:2:a22:2001::
SRH:(cafe:1:2:a22:2001::,SL = 0)
 2 cafe:1:2:a22:2001:: 0.50 ms 0.44 ms 0.50 ms
 3 cafe:1:2:a22:2001:: 0.52 ms
PE1#
```

Segment Routing Mapping Server Commands

This section describes each segment routing mapping server command.

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

<1-4294967295>

Color value

Command Mode

Tunnel policy mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#tunnel-policy policy1
```

```
(config-tnl-policy)#color 2

(config)#tunnel-policy policy1
(config-tnl-policy)#no color 2
```

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.

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 5.1.

Example

```
#configure terminal
(config)#tunnel-policy policy1

#configure terminal
(config)#no tunnel-policy policy1
```

tunnel-select-policy

Use this command to set tunnel-policy for a VRF 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

VRF mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#ip vrf vrf1
(config-vrf)#tunnel-select-policy p1
(config-vrf)#commit
(config-vrf)#
(config)#ip vrf vrf1
(config-vrf)#no tunnel-select-policy
(config-vrf)#commit
(config-vrf)#
```

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

Defaults

NA

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#show running-config tunnel-policy
!
tunnel-policy tp
  color1
!
```

Segment Routing Mapping Server Commands

This section describes each segment routing mapping server command.

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

<1-4294967295>

Color value

Command Mode

Tunnel policy mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#tunnel-policy policy1
(config-tnl-policy)#color 2

(config)#tunnel-policy policy1
(config-tnl-policy)#no color 2
```

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.

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 5.1.

Example

```
#configure terminal
(config)#tunnel-policy policy1

#configure terminal
(config)#no tunnel-policy policy1
```

tunnel-select-policy

Use this command to set tunnel-policy for a VRF 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

VRF mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal
(config)#ip vrf vrf1
(config-vrf)#tunnel-select-policy p1
(config-vrf)#commit
(config-vrf)#
(config)#ip vrf vrf1
(config-vrf)#no tunnel-select-policy
(config-vrf)#commit
(config-vrf)#
```

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

Defaults

NA

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#show running-config tunnel-policy
!
tunnel-policy tp
  color1
!
```

Seamless BFD Commands

This section describes each seamless bfd command.

hardware-profile seamless-bfd

Use this command to enable the hardware-profile for seamless BFD to successfully activate seamless BFD in the hardware. Configure the `hardware-profile seamless-bfd` command before configuring the [s-bfd sr policy \(page 1057\)](#) or [s-bfd discriminator \(page 1057\)](#) commands. Before disabling the hardware-profile, unconfigure the [s-bfd sr policy \(page 1057\)](#) or [s-bfd discriminator \(page 1057\)](#) commands.

Use the `disable` form of this command to disable the configured hardware-profile.



Note:

- After configuring `hardware-profile seamless-bfd` command, save the configuration and reboot the system.

- When downgrading to version 6.3.x from a higher-build version, configure the hardware-profile seamless-bfd disable.

Command Syntax

```
hardware-profile seamless-bfd enable
hardware-profile seamless-bfd disable
```

Parameter

None

Default

Disabled

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
#configure terminal
(config)#hardware-profile seamless-bfd enable
(config)#hardware-profile seamless-bfd disable
```

min-tx

Use this command to configure Seamless BFD transmit interval, and the hello multiplier value for Seamless BFD session.

Use the `no` form of the command to set the interval and multiplier to their default values.

Command Syntax

```
min-tx <3-999> multiplier <3-50>
no min-tx <3-999> multiplier <3-50>
```

Parameters

min-tx <3-999>

Set the desired transmit interval in milliseconds. Default transmit interval is 10 milliseconds.

multiplier <3-50>

Specifies the range of the BFD detection multiplier value. Default hello multiplier value is 3.

Default

None

Command Mode

S-BFD SR mode.

Applicability

This command was introduced in OcNOS version 6.0.0.

Example

```
#configure terminal
(config)#s-bfd sr policy 1
(config-sbfd)#min-tx 3 multiplier 5
```

s-bfd discriminator

Use this command to configure local S-BFD discriminator and optional required minimum receiver interval.

Use `no` form of this CLI to delete the local S-BFD discriminator.



Note: The configured S-BFD discriminator value should match with policy's endpoint value.

Command Syntax

```
s-bfd discriminator A.B.C.D (required-min-rx <3-999> | )
no s-bfd discriminator
```

Parameters

A.B.C.D

Local Discriminator in IP address format.

required-min-rx <3-999>

Specifies the range of the required minimum receive interval of control packets in milliseconds.

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 6.0.0.

Example

```
#configure terminal
(config)#s-bfd discriminator 1.2.3.4 required-min-rx 23
```

s-bfd sr policy

Use this command to configure Seamless BFD session for SR-TE.

Use `no` form of the command to unconfigure Seamless BFD session for SR-TE.

Command Syntax

```
s-bfd (sr) policy NAME  
no s-bfd (sr) policy NAME
```

Parameters

policy NAME

Specifies the SR-policy name.

Default

None

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 6.0.0.

Example

```
#configure terminal  
(config)#s-bfd sr policy 1  
(config-sbfd)#
```

shutdown

Use this command to configure Seamless BFD session in admin down state or to disable Seamless BFD session.

Use `no` form of this command to enable Seamless BFD session.

Command Syntax

```
shutdown  
no shutdown
```

Parameters

None

Command Mode

S-BFD SR mode.

Applicability

This command was introduced in OcNOS version 6.0.0.

Example

```
(config)#s-bfd sr policy 1
(config-sbfd)#shutdown
```

EVPN SRv6 Commands

This section describes the EVPN SRv6 commands.

evi-name

Use this command to name the EVPN SRv6 ID. Use the no form of this command to remove the name of the EVPN SRv6 ID.

Command Syntax

```
evi-name WORD
```

Parameters

WORD

EVI name of max size 10 character and should not be only numeric

Command Mode

EVPN SRv6 Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
PE1(config)#evpn srv6 id 70 xconnect target-srv6-id 80
PE1(config-evpn-srv6)#evi-name ELINE1
PE1(config-evpn-srv6)#
```

evpn srv6 enable

Use this command to enable evpn srv6 functionality.

Use the `no` version of this command to disable evpn srv6 functionality.

Command Syntax

```
evpn srv6 enable  
no evpn srv6 enable
```

Parameters

None

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
(config)#evpn srv6 enable  
(config)#no evpn srv6 enable
```

evpn srv6 id

Use this command to set the VPN identifier to create an EVPN SRv6 tunnel.

Use `evpn srv6 id` for creating ELAN and use `evpn srv6 xconnect` with source and target identifier for ELINE/XConnect.

Command Syntax

```
evpn srv6 id <1-16777215> (| xconnect target-srv6-id <1-16777215>)  
no evpn srv6 id <1-16777215>
```

Parameters

<1-16777215>

EVID

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
(config)#evpn srv6 id 100 xconnect target-srv6-id 200  
(coonfig)#no evpn srv6 id 100
```

evpn srv6 ip-global

Use this command to set the source IP address is used to establish BGP peering with neighbour SRv6 Nodes and to establish the EVPN SRv6 tunnels.

Use the `no` version of this command to delete the source IP address.

Command Syntax

```
evpn srv6 ip-global XX::XX  
no evpn srv6 ip-global XX::XX
```

Parameters

X:X::X:X

Ipv6 address type

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
(config)#evpn srv6 ip-global 2001::1  
(config)#no evpn srv6 ip-global 2001::1
```

evpn srv6 multihoming enable

Use this command to enable multihoming capability.

Use `no` form of this command to disable multihoming capability.

Command Syntax

```
evpn srv6 multihoming enable  
no evpn srv6 multihoming enable
```

Parameters

None

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 6.3.0.

Example

```
(config)#evpn srv6 multihoming enable  
(coonfig)#no evpn srv6 multihoming enable
```

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

Command Mode

EVPN SRv6 Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
OcNOS(config)#evpn srv6 id 70 xconnect target-srv6-id 80
OcNOS(config-evpn-srv6)# host-reachability-protocol evpn-bgp vrf3
```

locator

Use this command to map the srv6 locator to particular evpn instance.

Use `no` form of this command to disassociate the locator from evpn instance.

Command Syntax

```
locator WORD  
no locator
```

Parameters

WORD

Name of the Locator List

Command Mode

EVPN SRv6 Config mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
PE1(config)#evpn srv6 id 70 xconnect target-srv6-id 80  
PE1(config-evpn-srv6)#locator VPC13
```

show evpn srv6 xconnect

Use this command to display the sid details of EVPN tunnels for ELINE.

Command Syntax

```
show evpn srv6 xconnect (tunnel (sid | summary |) | id <1-16777215> |)
```

Parameters

tunnel

SRV6 tunnel status discovered by EVPN for VPWS

sid

SRV6 unicast SID's information for VPWS

summary

SRV6 tunnel status summary discovered by EVPN for VPWS

id

VPWS id

<1-16777215>

Range supported for VPWS-ID

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
OcNOS#
OcNOS#show evpn srv6 xconnect
id      tunnel
OcNOS#show evpn srv6 xconnect tunnel summary

Total number of entries: 1 [Installed: 0, Resolved: 1, Unresolved: 0]

OcNOS#show evpn srv6 xconnect tunnel sid
EVPN-SRV6 Network tunnel SID's
Evpn service type: ELINE
EVI-NAME: NA
PE IP: 2001::2
Status: Resolved
Xconnect information
Local Ethernet Tag Id: 70
Local UC-SID: 2981:40:a1:0:2::
Remote Ethernet Tag Id: 80
Remote UC-SID: 2981:40:a2:0:2::
Tunnel policy mapped: --

Total number of entries are 1

OcNOS#show evpn srv6 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
=====
70           ----      1500  80          xe7.100      --- Single Homed Port ---
           2001::2      1500  AC-NW  NW-SET

Total number of entries are 1
```

show running-config evpn srv6

Use this command to display the current running configuration of EVPN SRV6.

Command Syntax

```
show running-config evpn srv6
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
OcNOS#
OcNOS#show evpn srv6 xconnect
id      tunnel
OcNOS#show evpn srv6 xconnect tunnel summary

Total number of entries: 1 [Installed: 0, Resolved: 1, Unresolved: 0]

OcNOS#show evpn srv6 xconnect tunnel sid
EVPN-SRV6 Network tunnel SID's
Evpn service type: ELINE
EVI-NAME: NA
PE IP: 2001::2
Status: Resolved
Xconnect information
Local Ethernet Tag Id: 70
Local UC-SID: 2981:40:a1:0:2::
Remote Ethernet Tag Id: 80
Remote UC-SID: 2981:40:a2:0:2::
Tunnel policy mapped: --

Total number of entries are 1

OcNOS#show evpn srv6 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


```



```
=====
70      ----      1500 80      xe7.100      --- Single Homed Port ---
      2001::2      1500 AC-NW  NW-SET

Total number of entries are 1
```

show segment-routing srv6 services evpn

Use this command to display evpn srv6 service information and also mapped transport information.

Command Syntax

```
show segment-routing srv6 services (l3vpn( (vrf WORD) | ) | evpn ((id ID)|) |)
```

Parameters

evpn

Ethernet VPN

id

evpn instance identifier

ID

evpn vpws id

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 6.1.0.

Example

```
PE1#show segment-routing srv6 services evpn
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID              Nexthop              SRv6-Policy-Name
ELINE   >      vrf1      70              80              2981:40:a2:0:2::      2001::2
None
PE1#show segment-routing srv6 services evpn ?
id  evpn instance identifier
|   Output modifiers
>   Output redirection
<cr>

PE1#show segment-routing srv6 services evpn id ?
ID  evpn vpws id

PE1#show segment-routing srv6 services evpn id 70
Status codes: > - installed, * - selected, T - Uses service-mapped tunnel
Service Flags vrf      local-evpn-id  remote-evpn-
id      SID              Nexthop              SRv6-Policy-Name
ELINE   *      vrf1      70              80              2981:40:a2:0:2::      2001::2
None
PE1#
```

On-Demand Nexthop Commands

This section describes the segment routing on demand nexthop commands.

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A.B.C.D (IP constraints)

Use this command to set IP constraints for a dynamic candidate path. Use the no form of this command to remove an IP constraint from a dynamic candidate path.

Command Syntax

```
A.B.C.D (loose|strict|)
no A.B.C.D
```

Parameters

loose

Make this constraint loose

strict

Make this constraint strict

Default

By default, IP constraint is considered as loose.

Command Mode

ODN Candidate path constraint mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS#conf t
OcNOS (config) #segment-routing
OcNOS (config-sr) #traffic-engineering
OcNOS (config-sr-te) #on-demand-nexthop 101
OcNOS (config-sr-odn) #candidate-path 1
OcNOS (config-sr-odn-cp) #constraints
OcNOS (config-sr-odn-dyn-cp-cons) #1.1.1.1 loose
OcNOS (config-sr-odn-dyn-cp-cons) #end
```

affinity

Use this command to set a set affinity constraints for a dynamic candidate path.

Use the no form of this command to remove affinity constraints from a dynamic candidate path.

Command Syntax

```
affinity (exclude-any|include-all|include-any) ADMIN-GROUP-NAME
no affinity (exclude-any|include-all|include-any) ADMIN-GROUP-NAME
```

Parameters

exclude-any

Exclude any attribute

include-all

Include all attribute

include-any

Include any attribute

ADMIN-GROUP-NAME

Administrative group name

Default

By default, no affinity constraint is configured.

Command Mode

ODN Candidate path constraint mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS(config)#
OcNOS(config)#segment-routing
OcNOS(config-sr)#traffic-engineering
OcNOS(config-sr-te)#on-demand-nexthop 101
OcNOS(config-sr-odn)#candidate-path 1
OcNOS(config-sr-odn-cp)#constraints
OcNOS(config-sr-odn-dyn-cp-cons)#affinity include-all a1
OcNOS(config-sr-odn-dyn-cp-cons)#
```

binding-sid mpls label

Use this command to configure binding SID MPLS label value for a segment routing ODN template. Use the no form of this command to remove a binding SID

Command Syntax

```
binding-sid mpls label  
no binding-sid mpls label
```

Parameters

<16-15999>

MPLS Label

Default

By default, binding SID is not configured.

Command Mode

RSVP trunk mode

Segment routing policy mode

ODN mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #binding-sid mpls label 16  
OcNOS (config-sr-odn) #
```

candidate-path

Use this command to configure a candidate path for a segment routing policy.

Use the no form of this command to remove a candidate path from a segment routing policy

Command Syntax

```
candidate-path <1-65535>  
no candidate-path <1-65535>
```

Parameters

<1-65535>

Identifier for candidate path

Default

By default, no candidate path is configured.

Command Mode

Segment routing ODN template mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #candidate-path 11  
OcNOS (config-sr-odn-cp) #
```

constraints

Use this command to set constraints for a dynamic candidate path.

Use the no form of this command to remove constraints from a dynamic candidate path.

Command Syntax

```
constraints  
no constraints
```

Parameters

NA

Default

By default, constraints is not configured.

Command Mode

Candidate path mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #candidate-path 11  
OcNOS (config-sr-odn-cp) #constraints
```

cspf-retry-interval

Use this command to set the retry interval for two successive ISIS/OSPF CSPF computation for a candidate path.

Use the no form of this command to remove the CSPF retry interval

Command Syntax

```
cspf-retry-interval <1-600>  
no cspf-retry-interval
```

Parameters

<1-600>

Time in seconds between successive retries

Default

By default, the retry interval is 10 seconds

Command Mode

Segment-routing ODN mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #cspf-retry-interval 44  
OcNOS (config-sr-odn) #
```

cspf-retry-limit

Use this command to set the number of retries for ISIS/OSPF CSPF computation for a candidate path. Use the no form of this command to set the CSPF retry limit to its default (100).



Note: CSPF computation engine will compute cspf for a requested path after each retry interval until this limit is reached.

Command Syntax

```
cspf-retry-limit <1-65535>  
no cspf-retry-limit
```

Parameters

<1-65535>

Number of times CSPF should retry

Default

By default, the retry limit is 100

Command Mode

Segment-routing ODN mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #cspf-retry-limit 44  
OcNOS (config-sr-odn) #
```

dynamic-path

Use this command to set a candidate path as a dynamic path and request the computation engine to compute LSP. Use the no form of this command to remove a dynamic path type and computation engine from a candidate path



Notes: Candidate path type or computation engine cannot be updated.

Command Syntax

```
dynamic-path (isis (WORD|) | ospf (|) | pcep)
no dynamic-path (isis (WORD|) | (ospf |) | pcep)
```

Parameters

isis

Request ISIS WORD ISIS instance name

ospf

Request OSPF OSPF process identifier

pcep

Request PCEP

Default

By default, path type is not set and no computation engine is attached.

Command Mode

ODN Candidate path mode

Example

```
OcNOS(config)#
OcNOS(config)#segment-routing
OcNOS(config-sr)#traffic-engineering
OcNOS(config-sr-te)#on-demand-nexthop 101
OcNOS(config-sr-odn)#candidate-path 1
OcNOS(config-sr-odn-cp)#dynamic-path isis 1
OcNOS(config-sr-odn-cp)#
```

exit-odn-cp

Use this command to leave segment routing on-demand-nexthop candidate-path mode.

Command Syntax

```
exit-odn-cp
```

Parameters

None

Default

NA

Command Mode

Segment-routing ODN Candidate-path mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #  
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #candidate-path 1  
OcNOS (config-sr-odn-cp) #exit-odn-cp  
OcNOS (config-sr-odn) #  
OcNOS (config-sr-odn) #
```

exit-sr-odn

Use this command to leave segment routing on-demand-nexthop mode.

Command Syntax

```
exit-sr-odn
```

Parameters

None

Default

NA

Command Mode

Segment-routing ODN mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #segment-routing
OcNOS (config-sr) #traffic-engineering
OcNOS (config-sr-te) #on-demand-nexthop 101
OcNOS (config-sr-odn) #exit-sr-odn
OcNOS (config-sr-te) #
```

fallback flex-algo

Use this command to configure another flex-algo as a fallback mechanism for the primary flex-algo in SR-ODN template.

Use the **no** form of the command to remove the flex-algo as fallback option.

Command Syntax

```
fallback flex-algo <value>  
no fallback flex-algo <value>
```

Parameters

None

Default

Disabled

Command Mode

On Demand Nexthop Mode(ODN Mode)

Applicability

This command was introduced in OcNOS version 7.0.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #flex-algo 128  
OcNOS (config-sr-odn) #fallback flex-algo 129
```

fallback native-sr

Use this command to configure native-sr as a fallback mechanism for the primary flex-algo in SR-ODN template.

Use the **no** form of the command to remove the native-sr as fallback option.

Command Syntax

```
fallback native-sr
no fallback native-sr
```

Parameters

None

Default

Not configured

Command Mode

On Demand Nexthop Mode(ODN Mode)

Applicability

This command was introduced in OcNOS version 7.0.0.

Example

```
OcNOS (config) #segment-routing
OcNOS (config-sr) #traffic-engineering
OcNOS (config-sr-te) #on-demand-nexthop 101
OcNOS (config-sr-odn) #flex-algo 128
OcNOS (config-sr-odn) #fallback native-sr
```

flex-algo

Use this command to configure the flex-algo value associated with an SR-ODN instance.

Use the **no** form of the command to remove the flex-algo configured in an SR-ODN instance.

Command Syntax

```
flex-algo <128-255>  
no flex-algo
```

Parameters

<1-65535>

Flex-Algo value associated with ODN instance

Default

Not configured

Command Mode

On Demand Nexthop Mode(ODN Mode)

Applicability

This command was introduced in OcNOS version 7.0.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 105  
OcNOS (config-sr-odn) #flex-algo 128
```

hop-limit

Use this command to set hop-limit constraint for a dynamic candidate path.

Use the **no** form of this command to remove hop-limit constraint from a dynamic candidate path.

Command Syntax

```
hop-limit <1-32>  
no hop-limit
```

Parameters

<1-32>

Specifies the number of acceptable hops.

Default

Not configured

Command Mode

ODN Candidate path constraint mode

Applicability

Introduced in OcNOS version 7.0.0

Example

```
#configure terminal  
(config)#segment-routing  
(config-sr)#traffic-engineering  
(config-sr-te)#on-demand-nexthop 101  
(config-sr-odn)#candidate-path 1  
(config-sr-odn-cp)#dynamic-path isis 100  
(config-sr-odn-cp)#constraints  
(config-sr-odn-dyn-cp-cons)#hop-limit 3
```

metric-type

Use this command to set a metric-type for optimization objective.

Use the no form of this command to remove a metric type from a dynamic candidate path.

Command Syntax

```
metric-type (igp|te) (bound |)  
no metric-type (igp|te)
```

Parameters

igp

IGP metric

te

TE metric

bound

Maximum allowed metric for computed path

<1- 4294967295>

Maximum allowed metric value

Default

By default, no metric and bound is configured.

Command Mode

Candidate path constraint mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS(config)#  
OcNOS(config)#segment-routing  
OcNOS(config-sr)#traffic-engineering  
OcNOS(config-sr-te)#on-demand-nexthop 101  
OcNOS(config-sr-odn)#candidate-path 1  
OcNOS(config-sr-odn-cp)#dynamic-path pcep  
OcNOS(config-sr-odn-cp)#constraints  
OcNOS(config-sr-odn-dyn-cp-cons)#metric-type igp
```

on-demand-nexthop

Use this command to configure a ODN template with color.

Use the no form of the command to remove an ODN template

Command Syntax

```
on-demand-nexthop <1-4294967295>
no on-demand-nexthop
```

Parameters

<1-4294967295>

color value for the ODN template

Default

By default, ODN template is not configured.

Command Mode

Traffic-engineering mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #segment-routing
OcNOS (config-sr) #traffic-engineering
OcNOS (config-sr-te) #on-demand-nexthop 101
OcNOS (config-sr-odn) #
OcNOS (config-sr-odn) #
```

preference

Use this command to set a preference value for an ODN candidate path.

Use the no form of this command to remove a preference value from an ODN candidate path.

Command Syntax

```
preference <1-65535>  
no preference
```

Parameters

<1-65535>

Preference for candidate path.

Default

By default, preference value is 100 for a candidate path.

Command Mode

ODN Candidate path mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS (config) #segment-routing  
OcNOS (config-sr) #traffic-engineering  
OcNOS (config-sr-te) #on-demand-nexthop 101  
OcNOS (config-sr-odn) #candidate-path 1  
OcNOS (config-sr-odn-cp) #preference 111  
OcNOS (config-sr-odn-cp) #
```

show segment-routing policy

Use this command to display segment routing policy information for both configured SR-policy and ODN created Policy.

Command Syntax

Use this command to display basic/detailed information for all SR policies:

```
show segment-routing policy (detail|)
```

Use this command to check details of a particular policy or a particular candidate path:

```
show segment-routing policy WORD (candidate-path origin (local|pce)|)
```

Use this command to check if a policy has candidate-paths with the given origin:

```
show segment-routing policy candidate-path origin (local|pce)
```

Parameters

detail

Display details of segment routing policies

WORD

Segment routing policy name

<1-4294967295>

Candidate-path identifier

local

Locally originated candidate path

pce

PCE originated candidate path

Command Mode

Privileged Exec mode

Applicability

This command was introduced in OcNOS version 6.2.0.

Example

```
OcNOS#
rtr29#show segment-routing policy detail

Policy-Name: policy_odn_1_1_45.45.45.45    Color 1      End-point 45.45.45.45    Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:02:23
State Transition Count: 1
CSPF Retry Limit: 100    CSPF Retry Interval: 10
ODN-Policy: True
Binding SID :
BSID: 0
```

```
Alloc mode: Dynamic
Oper State: Programmed
```

```
CP ID: 1, Active
  Preference: 100      Path Type: Dynamic(isis)    CP Origin: Local
  CP state: Valid
  Segment List:
  Total no. of segments: 1
    Segment0[LABEL]: Label :16045
  Out-if: xe7          Out-label-stack: 3
  Computed TE Metric: 10
  Attributes:
    Configured:
      Affinity:
      Metric-type: TE
      IP Constraints:
```

PATH COMPUTATION ELEMENT COMMUNICATION PROTOCOL CONFIGURATION

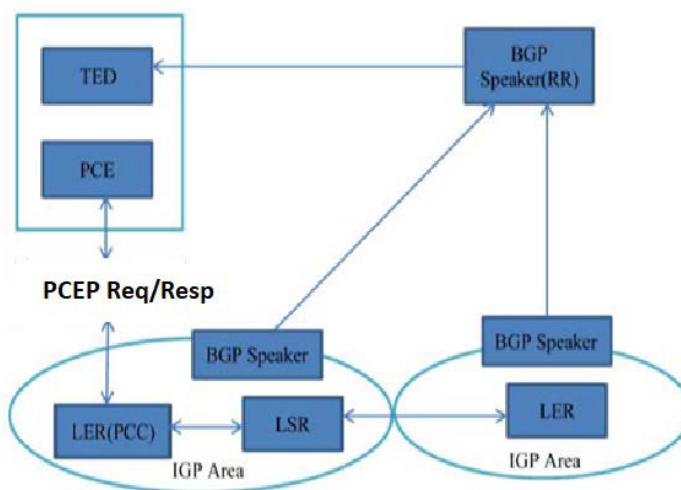
BGP Link-State and PCEP Configuration

This section contains configurations for Path Computation Element Protocol (PCEP) and the BGP Link-State capability.

BGP-LS

BGP-LS describes a mechanism by which Link-State (LS) and Traffic Engineering (TE) information from IGP can be collected from networks and shared with external components using BGP. This is achieved using a new BGP Network Layer Reachability Information (NLRI) encoding format. The mechanism is applicable to physical and virtual links. Applications of this technique include Application-Layer Traffic Optimization (ALTO) servers and Path Computation Elements (PCEs). These components, while external to the network, require network state information on a real time basis. Specifically, they require link-state database information of each IGP node (OSPF) from the entire network. The BGP protocol is used to collect the necessary information and to share with the external components – this is achieved using a NLRI encoding format.

Figure 49. BGP-LS Architecture



BGP uses AFI (16388) and SAFI (71) for distributing the Link state and Traffic engineering information.

It uses Link State NLRI that describes links, nodes, and prefixes comprised of IGP link-state information. A new BGP path attribute called BGP-LS attribute is defined to carry the link, node, prefix properties, and attributes like link and prefix metric or auxiliary Router-IDs of nodes

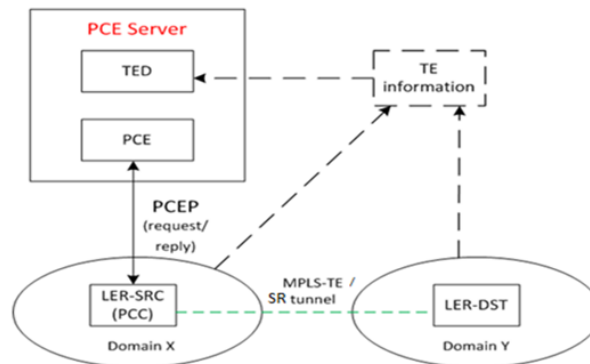
PCEP

A Path Computation Element (PCE) is an entity (component, application, or network node) that is capable of computing a network path or route based on a network graph and applying computational constraints. A Path Computation Client (PCC) is any client application requesting a path computation to be performed by a PCE. A Path Computation Element supports requests for path computation issued by a Path Computation Client.

The PCE operates on a network graph in order to compute paths based on the path computation request(s) issued by the PCC(s). The path computation request will include the source and destination of the paths to be computed

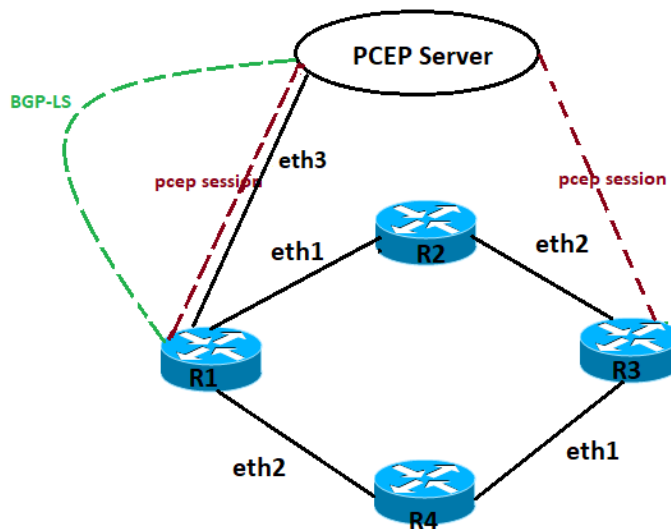
and a set of constraints to be applied during the computation, and it may also include an objective function. The PCE response includes the computed paths or the reason for a failed computation.

Figure 50. PCEP Architecture



Topology

Figure 51. PCEP and BGP configuration topology



Configuration for PCEP AND BGP-LS

R1

The following are the step-by-step configurations on the R1 router.

```
R1#configure terminal
```

```
Enter configure mode.
```

R1(config)#interface lo	Enter interface mode.
R1(config-if)#ip address 1.1.1.1/32 secondary	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)# prefix-sid absolute 16001 no-php	Configure prefix SID absolute value.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface eth1	Enter interface mode.
R1(config-if)#ip address 11.1.1.1/24	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#isis network point-to-point	ISIS network type as point-to-point
R1(config-if)#label-switching	Enable label switching.
R1(config)#interface eth2	Enter interface mode.
R1(config-if)#ip address 12.1.1.1/24	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#label-switching	Enable label switching.
R1(config-if)#isis network point-to-point	ISIS network type as point-to-point
R1(config-if)#exit	Exit interface mode.
R1(config)#interface eth3	Enter interface mode.
R1(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface towards PCE
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#label-switching	Enable label switching.
R1(config-if)#isis network point-to-point	Network type as point-to-point
R1(config-if)#exit	Exit interface mode.
R1(config)#router isis 1	Set the routing process ID .
R1(config-router)#is-type level-1	Configure is-type.
R1(config-router)#distribute bgp-ls	Link State distribution to BGP
R1(config-router)#metric-style wide level-1	Configure metric style as wide.
R1(config-router)# net 49.0001.0000.0000.0011.00	Configure Network entity title (NET).
R1(config-router)#mpls traffic-eng router-id 1.1.1.1	Enable MPLS Traffic Engineering under router process.
R1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R1(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R1(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range

R1(config-router)#segment-routing mpls	Enable segment routing under router process.
R1(config-router)#exit	Exit router mode.
R1(config)# router bgp 100	Configure router BGP in AS 100
R1(config-router)# bgp router-id 1.1.1.1	Router identifier for BGP
R1(config-router)# neighbor 33.33.33.33 remote-as 100	Configure neighbor in remote-as 100
R1(config-router)# neighbor 33.33.33.33 update-source lo	Configure neighbor with update-source loopback
R1(config-router)# address-family link-state link-state	Enter link-state Address family mode
R1(config-router-af)# neighbor 33.33.33.33 activate	Activate PCE neighbor
R1(config-router-af)# exit-address-family	Exit from Address Family configuration mode
R1(config-router)#exit	Exit router mode.
R1(config)# pce configuration 1	Configure Path Computation Client with entity 1
R1(config-pcep)#capability	Enter capabilities submodule
R1(config-pcep-cap)#segment-routing pcep	Segment routing capability for PCE
R1(config-pcep-cap)# pce instantiation	PCE Initiated LSP Instantiation
R1(config-pcep-cap)# exit-capability	Exit from PCEP Entity Capability mode
R1(config-pcep)# update-source 1.1.1.1	Source of routing updates
R1(config-pcep)# peer-address ipv4 33.33.33.33	Configure peer address
R1(config-pcep)# exit	Exit PCEP mode.

R2

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Enter interface mode.
R2(config-if)#ip address 2.2.2.2/32 secondary	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)# prefix-sid absolute 16002 no-php	Configure prefix SID absolute value.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface eth1	Enter interface mode.
R2(config-if)#ip address 11.1.1.2/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)#isis network point-to-point	ISIS network type as point-to-point

R2(config-if)#label-switching	Enable label switching.
R2(config)#interface eth2	Enter interface mode.
R2(config-if)#ip address 6.1.1.1/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)#label-switching	Enable label switching.
R2(config-if)#isis network point-to-point	ISIS network type as point-to-point
R2(config-if)#exit	Exit interface mode.
R2(config)#router isis 1	Set the routing process ID .
R2(config-router)#is-type level-1	Configure is-type.
R2(config-router)#metric-style wide level-1	Configure metric style as wide.
R2(config-router)# net 49.0001.0000.0000.0022.00	Configure Network entity title (NET).
R2(config-router)#mpls traffic-eng router-id 2.2.2.2	Enable MPLS Traffic Engineering under router process.
R2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R2(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R2(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range
R2(config-router)#segment-routing mpls	Enable segment routing under router process.
R2(config-router)#exit	Exit router mode.

R3

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Enter interface mode.
R3(config-if)#ip address 3.3.3.3/32 secondary	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)# prefix-sid absolute 16003 no-php	Configure prefix SID absolute value.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface eth1	Enter interface mode.
R3(config-if)#ip address 9.1.1.2/24	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#isis network point-to-point	ISIS network type as point-to-point
R3(config-if)#label-switching	Enable label switching.

R3(config)#interface eth2	Enter interface mode.
R3(config-if)#ip address 6.1.1.2/24	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#label-switching	Enable label switching.
R3(config-if)#isis network point-to-point	ISIS network type as point-to-point
R3(config-if)#exit	Exit interface mode.
R3(config)#router isis 1	Set the routing process ID .
R3(config-router)#is-type level-1	Configure is-type.
R3(config-router)#distribute bgp-ls	Link State distribution to BGP
R3(config-router)#metric-style wide level-1	Configure metric style as wide.
R3(config-router)# net 49.0001.0000.0000.0033.00	Configure Network entity title (NET).
R3(config-router)#mpls traffic-eng router-id 3.3.3.3	Enable MPLS Traffic Engineering under router process.
R3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R3(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R3(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range
R3(config-router)#segment-routing mpls	Enable segment routing under router process.
R3(config-router)#exit	Exit router mode.
R3(config)# pce configuration 1	Configure Path Computation Client
R3(config-pcep)#capability	Specify capabilities of entity
R3(config-pcep-cap)#segment-routing pcep	Segment routing for PCE
R3(config-pcep-cap)# pce instantiation	PCE Initiated LSP Instantiation
R3(config-pcep-cap)# exit-capability	Exit from PCEP Entity Capability mode
R3(config-pcep)# update-source 3.3.3.3	Source of routing updates
R3(config-pcep)# peer-address ipv4 33.33.33.33	Configure peer address
R3(config-pcep)# exit	Exit PCEP mode.

R4

The following are the step-by-step configurations on the R4 router.

R4#configure terminal	Enter configure mode.
R4(config)#interface lo	Enter interface mode.
R4(config-if)#ip address 4.4.4.4/32 secondary	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

R4(config-if)# prefix-sid absolute 16004 no-php	Configure prefix SID absolute value.
R4(config-if)#exit	Exit interface mode.
R4(config)#interface eth1	Enter interface mode.
R4(config-if)#ip address 9.1.1.1/24	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R4(config-if)#isis network point-to-point	ISIS network type as point-to-point
R4(config-if)#label-switching	Enable label switching.
R4(config)#interface eth2	Enter interface mode.
R4(config-if)#ip address 12.1.1.2/24	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R4(config-if)#label-switching	Enable label switching.
R4(config-if)#isis network point-to-point	ISIS network type as point-to-point
R4(config-if)#exit	Exit interface mode.
R4(config)#router isis 1	Set the routing process ID .
R4(config-router)#is-type level-1	Configure is-type.
R4(config-router)#metric-style wide level-1	Configure metric style as wide.
R4(config-router)# net 49.0001.0000.0000.0044.00	Configure Network entity title (NET).
R4(config-router)#mpls traffic-eng router-id 4.4.4.4	Enable MPLS Traffic Engineering under router process.
R4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R4(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R4(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range
R4(config-router)#segment-routing mpls	Enable segment routing under router process.
R4(config-router)#exit	Exit router mode.

Validation

PCEP Peer

Validation for PCEP Peer

```
R1#show pcep peer

=====
Path Computation Client Connection Details :
=====

PCEP entity id : 1
=====
```

Peer Info

```

-----
PCE Server IP      : 33.33.33.33
PCEP Source IP    : 1.1.1.1
PCEP Local session-id : 2
PCEP Remote session-id : 0
Session Connect Retry : 0
Session Connect due in : 0 sec
OpenRetry          : 0
Open wait due in   : 0 sec
Keep wait due in   : 0 sec
Keep alive timer due in : 3 sec
Peer Keep-alive value : 30 sec
Peer Dead timer value : 120 sec
Peer Dead timer due in : 93 sec
Peer Overloaded     : No
Peer Overload due in : 0 sec
LocalOK             : 1
RemoteOK            : 1
Max unknown messages : 0
FSM State           : Up
Total FSM State changes : 4
Peer Up time        : 00:02:26
Flap Limit Timer value : 300 Sec
Local Capabilities :
  Stateful PCE Capability : Yes
  LSP Instantiation       : Yes
  SR PCE Capability       : Yes
Remote Capabilities :
  Stateful PCE Capability : Yes
  LSP Update Capability   : Yes
  LSP Instantiation       : Yes
  SR PCE Capability       : Yes

```

R1# show pcep statistics

```

=====
Path Computation Client Statistics Details :
=====

```

```

Entity Index      : 1
PCE Server IP     : 33.33.33.33
Open sent         : 2
Open rcv          : 2
Path request sent  : 0
Path response rcv  : 0
Path report sent   : 2
Path update rcv    : 0
Path initiate rcv  : 0
Error Sent         : 0
Error received     : 0
Notification Sent  : 0
Notification received: 0
Keepalive Sent     : 23
Keepalive received : 20
Unknown rcv        : 0
Corrupt rcv        : 0
Request cancelled   : 0
Request rejected    : 0
Request Timed out   : 0
Request comp failed : 0
Request with reply  : 0

```

R3#show pcep peer

```

=====
Path Computation Client Connection Details :
=====

```

```

PCEP entity id : 1
=====
Peer Info
-----
PCE Server IP           : 33.33.33.33
PCEP Source IP          : 3.3.3.3
PCEP Local session-id   : 3
PCEP Remote session-id  : 0
Session Connect Retry   : 0
Session Connect due in  : 0 sec
OpenRetry               : 0
Open wait due in        : 0 sec
Keep wait due in        : 0 sec
Keep alive timer due in  : 26 sec
Peer Keep-alive value    : 30 sec
Peer Dead timer value    : 120 sec
Peer Dead timer due in   : 116 sec
Peer Overloaded          : No
Peer Overload due in     : 0 sec
LocalOK                 : 1
RemoteOK                : 1
Max unknown messages     : 0
FSM State               : Up
Total FSM State changes  : 5
Peer Up time            : 00:03:03
Flap Limit Timer value   : 300 Sec
Local Capabilities :
  Stateful PCE Capability : Yes
  LSP Instantiation       : Yes
  SR PCE Capability       : Yes
Remote Capabilities :
  Stateful PCE Capability : Yes
  LSP Update Capability   : Yes
  LSP Instantiation       : Yes
  SR PCE Capability       : Yes

```

BGP-LS

Validation for BGP-LS

```

R1#show bgp link-state link-state summary
BGP router identifier 1.1.1.1, local AS number 100
BGP table version is 28
0 BGP AS-PATH entries
0 BGP community entries

Neighbor          V    AS  MsgRcv   MsgSen  TblVer   InQ   OutQ   Up/Dow
n  State/PfxRcd
33.33.33.33        4    100    39      177     28      0      0  00:07:20
0

Total number of neighbors 1

Total number of Established sessions 1
R1#
R1#show bgp link-state link-state
BGP router identifier 1.1.1.1, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
[V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0011.00]]/208

```



```

[V][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.00]]/208
[V][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.01]]/208
[V][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0033.00]]/208
[V][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0044.00]]/208
[V][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.2222.00]]/208
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0011.00]][R[c100][b1.1.1.1][s0000.000
0.0022.00]][L[i11.1.1.1][n11.1.1.2]]/328
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0011.00]][R[c100][b1.1.1.1][s0000.000
0.0044.00]][L[i12.1.1.1][n12.1.1.2]]/328
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0011.00]][R[c100][b1.1.1.1][s0000.000
0.2222.00]][L[i20.1.1.1][n20.1.1.2]]/328
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.00]][R[c100][b1.1.1.1][s0000.000
0.0011.00]][L[i11.1.1.2][n11.1.1.1]]/328
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.01]][R[c100][b1.1.1.1][s0000.000
0.0011.00]]/264
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.01]][R[c100][b1.1.1.1][s0000.000
0.0022.00]]/264
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0033.00]][R[c100][b1.1.1.1][s0000.000
0.0044.00]][L[i9.1.1.2][n9.1.1.1]]/328
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0044.00]][R[c100][b1.1.1.1][s0000.000
0.0011.00]][L[i12.1.1.2][n12.1.1.1]]/328
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0044.00]][R[c100][b1.1.1.1][s0000.000
0.0033.00]][L[i9.1.1.1][n9.1.1.2]]/328
[E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.2222.00]][R[c100][b1.1.1.1][s0000.000
0.0011.00]][L[i20.1.1.2][n20.1.1.1]]/328
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0011.00]][P[p11.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0011.00]][P[p12.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0011.00]][P[p20.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0011.00]][P[p1.1.1.1/32]]/248
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.00]][P[p6.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.00]][P[p11.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0022.00]][P[p2.2.2.2/32]]/248
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0033.00]][P[p6.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0033.00]][P[p9.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0033.00]][P[p3.3.3.3/32]]/248
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0044.00]][P[p9.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0044.00]][P[p12.1.1.0/24]]/240
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0044.00]][P[p4.4.4.4/32]]/248
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.2222.00]][P[p20.1.1.0/30]]/248
[T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.2222.00]][P[p33.33.33.33/32]]/248
NLRIs, Total: 31, Node: 6, Link: 10, Prefix: 15
R1#
R1#show bgp neighbors
BGP neighbor is 33.33.33.33, remote AS 100, local AS 100, internal link
  BGP version 4, local router ID 1.1.1.1, remote router ID 33.33.33.33
  BGP state = Established, up for 00:07:43
  Last read 00:00:08, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    4-Octet ASN Capability: received
    Address family IPv4 Unicast: advertised
    Address family Link-State Link-State: advertised and received
  Received 40 messages, 0 notifications, 0 in queue
  Sent 177 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: Link-State Link-State
    BGP table version 28, neighbor version 28
    Index 1, Offset 0, Mask 0x2
    Community attribute sent to this neighbor (both)

```

```
0 accepted prefixes
31 announced prefixes

Connections established 2; dropped 1
Local host: 1.1.1.1, Local port: 35177
Foreign host: 33.33.33.33, Foreign port: 179
Nexthop: 1.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:49:08, due to Hold Timer Expired (Notification sent)
Notification Error Message: (Hold Timer Expired/No sub-error code)
```

BGP Link State with ISIS Segment Routing

This section shows configuration of BGP link state with ISIS segment routing.

Overview

Segment Routing (SR) allows a head end node to steer a packet flow along any path. Intermediate per-flow states are eliminated due to source routing. The head end node is said to steer a flow into a Segment Routing Policy (SR Policy). The header of a packet steered in an SR Policy is augmented with the ordered list of segments associated with that SR Policy. This feature is supported for MPLS instantiations.

BGP-LS describes a mechanism by which Link-State (LS) and Traffic Engineering (TE) information from IGP can be collected from networks and shared with external components using the BGP. This is achieved using a new BGP Network Layer Reachability Information (NLRI) encoding format. The mechanism is applicable to physical and virtual links. Applications of this technique include Path Computation Elements (PCEs). These components, while external to the network, require network state information on a real time basis. Specifically, they require link-state database information of each IGP node from the entire network. BGP protocol is used to collect the necessary information and to share with the external components and this is achieved using a NLRI encoding format.

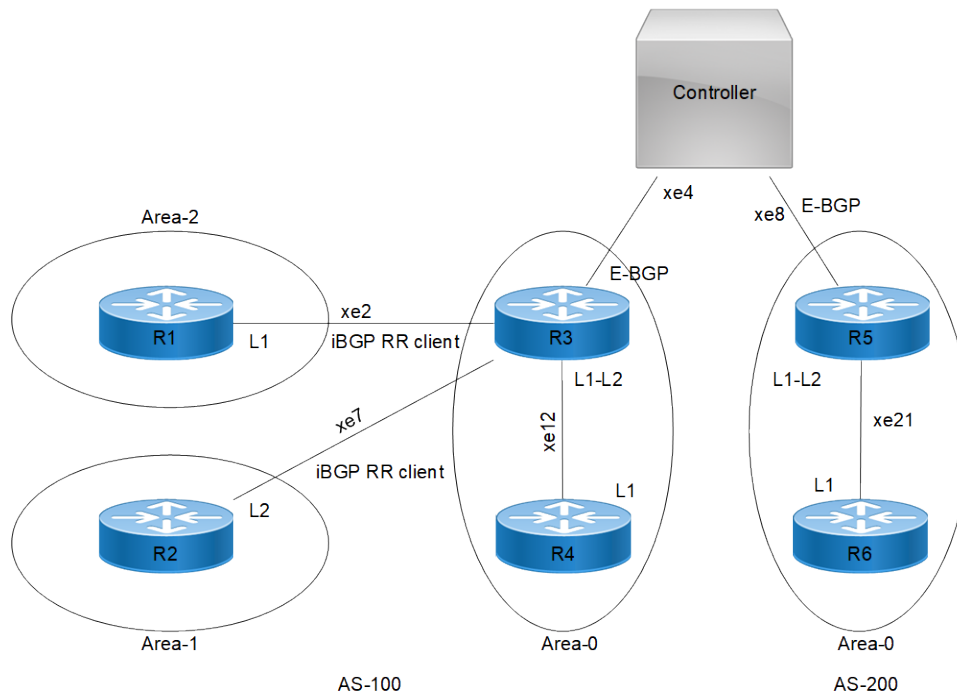
An NLRI is defined to advertise SR Policy to the headend of that policy. New sub-TLVs for the Tunnel Encapsulation Attribute are defined to carry SR related information.



Note: We recommended using prefix-sid index, when have different SRGB configured on different routers there is very high chance that absolute value may lie outside SRGB and MPLS entries may not get installed, so we should use "prefix-sid index".

Topology

[Figure 52. ISIS segment routing with BGP link state \(page 1103\)](#) shows 6 routers and 1 controller. R1, R2, R3, and R4 belong to AS-100 and R5 and R6 belongs to AS-200, Controller belongs to AS-300 R1 and R2 has an iBGP (BGP-LS) session with R3. R3 and R5 have an eBGP session with the controller with BGP-LS.

Figure 52. ISIS segment routing with BGP link state

Configuration

R1: Interface

The following are the step-by-step configurations on the R1 router.

R1#configure terminal	Enter configure mode
R1(config)#hostname R1	Configure hostname
R1(config)#interface lo	Enter interface mode for loopback interface.
R1(config-if)#ip address 1.1.1.1/32 secondary	Configure IPv4 address.
R1(config-if)#ip router isis 1	Configure Router-isis.
R1(config-if)#prefix-sid index 100	Configure Prefix-sid
R1(config-if)#exit	Exit interface mode
R1(config)#interface xe2	Enter interface mode for xe2 interface.
R1(config-if)#ip address 10.1.1.1/24	Configure IPv4 address.
R1(config-if)# label-switching	Enable label switching
R1(config-if)#ip router isis 1	Configure Router-isis.
R1(config-if)#exit	Exit interface mode

R1: ISIS

The following are the step-by-step configurations on the R1 router.

R1(config)#router isis 1	Enter ISIS router mode
R1(config-router)#is-type level-1	Configure IS-type.
R1(config-router)#metric-style wide	Configure Metric-style.
R1(config-router)#mpls traffic-eng router-id 1.1.1.1	Configure MPLS TE router-id.
R1(config-router)#mpls traffic-eng level-1	Configure MPLS TE Level-1.
R1(config-router)#isis segment-routing global block 18000 20999	Configure SRGB range.
R1(config-router)#segment-routing mpls	Enabling Segment-Routing.
R1(config-router)#net 49.0000.0000.0000.0001.00	Configure net-id.
R1(config-router)#distribute bgp-ls	Distributing BGP-LS.
R1(config-router)#exit	Exit ISIS router mode

R1: BGP

The following are the step-by-step configurations on the R1 router.

R1(config)#router bgp 100	Enter BGP router mode
R1(config)#bgp router-id 1.1.1.1	Configure BGP router-id
R1(config-router)#neighbor 3.3.3.3 remote-as 100	Configure neighbor with remote-as.
R1(config-router)#neighbor 3.3.3.3 update-source lo	Configure neighbor with update-source.
R1(config-router)#address-family link-state link-state	Entering link-state link-state address family.
R1(config-router-af)#neighbor 3.3.3.3 activate	Activating Neighbor in link-state link-state address family.
R1(config-router)#exit	Exit BGP router mode

R2: Interface

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Enter configure mode
R2(config)#hostname R2	Configure hostname
R2(config)#interface lo	Enter interface mode for loopback interface.
R2(config-if)#ip address 2.2.2.2/32 secondary	Configure IPv4 address.
R2(config-if)#ip router isis 1	Configure Router-isis.
R2(config-if)#prefix-sid index 400	Configure Prefix-sid
R2(config-if)#exit	Exit interface mode
R2(config)#interface xe7	Enter interface mode for xe7 interface.

R2(config-if)#ip address 20.1.1.1/24	Configure IPv4 address.
R2(config-if)#label-switching	Enable lable switching
R2(config-if)#ip router isis 1	Configure Router-isis.
R2(config-if)#exit	Exit interface mode

R2: ISIS

The following are the step-by-step configurations on the R2 router.

R2(config)#router isis 1	Enter ISIS router mode
R2(config-router)#is-type level-2	Configure IS-type.
R2(config-router)#metric-style wide	Configure Metric-style.
R2(config-router)#mpls traffic-eng router-id 2.2.2.2	Configure MPLS TE router-id.
R2(config-router)#mpls traffic-eng level-2	Configure MPLS TE Level-2.
R2(config-router)#isis segment-routing global block 19000 21999	Configure SRGB range
R2(config-router)#segment-routing mpls	Enabling Segment-Routing.
R2(config-router)#net 49.0001.0000.0000.0002.00	Configure net-id.
R2(config-router)#distribute bgp-ls	Distributing BGP-LS.
R2(config-router)#exit	Exit ISIS router mode

R2: BGP

The following are the step-by-step configurations on the R2 router.

R2(config)#router bgp 100	Enter BGP router mode
R2(config)#bgp router-id 2.2.2.2	Configure BGP router-id
R2(config-router)#neighbor 3.3.3.3 remote-as 100	Configure neighbor with remote-as.
R2(config-router)#neighbor 3.3.3.3 update-source lo	Configure neighbor with update-source.
R2(config-router)#address-family link-state link-state	Entering link-state link-state address family.
R2(config-router-af)#neighbor 3.3.3.3 activate	Activating Neighbor in link-state link-state address family.
R2(config-router)#exit	Exit BGP router mode

R3: Interface

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Enter configure mode
-----------------------	----------------------

R3(config)#hostname R3	Configure hostname
R3(config)#interface lo	Enter interface mode for loopback interface.
R3(config-if)#ip address 3.3.3.3/32 secondary	Configure IPv4 address.
R3(config-if)#ip router isis 1	Configure Router-isis.
R3(config-if)#prefix-sid index 300	Configure Prefix-sid
R3(config-if)#exit	Exit interface mode
R3(config)#interface xe2	Enter interface mode for xe2 interface.
R3(config-if)#ip address 10.1.1.2/24	Configure IPv4 address.
R3(config-if)#ip router isis 1	Configure Router-isis.
R3(config-if)# label-switching	Enable label switching
R3(config-if)#exit	Exit interface mode
R3(config)#interface xe7	Enter interface mode for xe7 interface.
R3(config-if)#ip address 20.1.1.2/24	Configure IPv4 address.
R3(config-if)#ip router isis 1	Configure Router-isis.
R3(config-if)# label-switching	Enable label switching
R3(config-if)#exit	Exit interface mode
R3(config)#interface xe12	Enter interface mode for xe12 interface.
R3(config-if)#ip address 30.1.1.1/24	Configure IPv4 address.
R3(config-if)# label-switching	Enable label switching
R3(config-if)#ip router isis 1	Configure Router-isis.
R3(config-if)#exit	Exit interface mode
R3(config)#interface xe4	Enter interface mode for xe4 interface.
R3(config-if)#ip address 40.1.1.1/24	Configure IPv4 address.
R3(config-if)# label-switching	Enable label switching
R3(config-if)#exit	Exit interface mode

R3: ISIS

The following are the step-by-step configurations on the R3 router.

R3(config)#router isis 1	Enter ISIS router mode
R3(config-router)#is-type level-1-2	Configure IS-type.
R3(config-router)#metric-style wide	Configure Metric-style.
R3(config-router)#mpls traffic-eng router-id 3.3.3.3	Configure MPLS TE router-id.
R3(config-router)#mpls traffic-eng level-1	Configure MPLS TE Level-1.
R3(config-router)#mpls traffic-eng level-2	Configure MPLS TE Level-2.
R3(config-router)#isis segment-routing global	Configure SRGB range.

block 17500 22300	
R3(config-router)#segment-routing mpls	Enabling Segment-Routing.
R3(config-router)#net 49.0000.0000.0000.0003.00	Configure net-id.
R3(config-router)#distribute bgp-ls	Distributing BGP-LS.
R3(config-router)#exit	Exit from router isis mode.

R3: BGP

The following are the step-by-step configurations on the R3 router.

R3(config)#router bgp 100	Enter BGP router mode
R3(config)#bgp router-id 3.3.3.3	Configure BGP router-id
R3(config-router)#neighbor 1.1.1.1 remote-as 100	Configure neighbor with remote-as.
R3(config-router)#neighbor 1.1.1.1 update-source lo	Configure neighbor with update-source.
R3(config-router)#neighbor 2.2.2.2 remote-as 100	Configure neighbor with remote-as.
R3(config-router)#neighbor 2.2.2.2 update-source lo	Configure neighbor with update-source.
R3(config-router)#address-family link-state link-state	Entering link-state link-state address family.
R3(config-router-af)#neighbor 1.1.1.1 activate	Activating Neighbor in link-state link-state address family.
R3(config-router-af)#neighbor 2.2.2.2 activate	Activating Neighbor in link-state link-state address family.
R3(config-router-af)#exit	Exit from BGP address family mode
R3(config-router)#exit	Exit from bgp router mode
R3(config)#router bgp 100	Enter BGP router mode
R3(config-router)#neighbor 40.1.1.2 remote-as 300	Configure neighbor with remote-as.
R3(config-router)#address-family link-state link-state	Entering link-state link-state address family.
R3(config-router-af)#neighbor 40.1.1.2 activate	Activating Neighbor in link-state link-state address family.
R3(config-router-af)#exit	Exit from BGP address family mode
R3(config-router)#exit	Exit from router bgp mode

R4: Interface

The following are the step-by-step configurations on the R4 router.

R4#configure terminal	Enter configure mode
R4(config)#hostname R4	Configure hostname

R4(config)#interface lo	Enter interface mode for loopback interface.
R4(config-if)#ip address 4.4.4.4/32 secondary	Configure IPv4 address.
R4(config-if)#ip router isis 1	Configure Router-isis.
R4(config-if)#prefix-sid index 500	Configure Prefix-sid
R4(config-if)#exit	Exit interface mode
R4(config)#interface xe12	Enter interface mode for xe12 interface.
R4(config-if)#ip address 30.1.1.2/24	Configure IPv4 address.
R4(config-if)#label-switching	Enable label switching
R4(config-if)#ip router isis 1	Configure Router-isis.
R4(config-if)#exit	Exit interface mode

R4: ISIS

The following are the step-by-step configurations on the R4 router.

R4(config)#router isis 1	Enter ISIS router mode
R4(config-router)#is-type level-1	Configure IS-type.
R4(config-router)#metric-style wide	Configure Metric-style.
R4(config-router)#mpls traffic-eng router-id 4.4.4.4	Configure MPLS TE router-id.
R4(config-router)#mpls traffic-eng level-1	Configure MPLS TE Level-1.
R4(config-router)#isis segment-routing global block 16500 23800	Configure SRGB range (default: 16-23999).
R4(config-router)#segment-routing mpls	Enabling Segment-Routing.
R4(config-router)#net 49.0000.0000.0000.0004.00	Configure net-id.
R4(config-router)#exit	Exit from router isis mode.

R5: Interface

The following are the step-by-step configurations on the R5 router.

R5#configure terminal	Enter configure mode
R5(config)#hostname R5	Configure hostname
R5(config)#interface lo	Enter interface mode for loopback interface.
R5(config-if)#ip address 5.5.5.5/32 secondary	Configure IPv4 address.
R5(config-if)#ip router isis 1	Configure Router-isis.
R5(config-if)#label-switching	Enable label switching
R5(config-if)#prefix-sid index 700	Configure Prefix-sid
R5(config-if)#exit	Exit interface mode

R5(config)#interface xe21	Enter interface mode for xe21 interface.
R5(config-if)#ip address 60.1.1.1/24	Configure IPv4 address.
R5(config-if)#ip router isis 1	Configure Router-isis.
R5(config-if)#exit	Exit interface mode
R5(config)#interface xe8	Enter interface mode for xe8 interface.
R5(config-if)#ip address 50.1.1.1/24	Configure IPv4 address.
R5(config-if)# label-switching	Enable label switching
R5(config-if)#exit	Exit interface mode

R5: ISIS

The following are the step-by-step configurations on the R5 router.

R5(config)#router isis 1	Enter ISIS router mode
R5(config-router)#is-type level-1-2	Configure IS-type.
R5(config-router)#metric-style wide	Configure Metric-style.
R5(config-router)#mpls traffic-eng router-id 5.5.5.5	Configure MPLS TE router-id.
R5(config-router)#mpls traffic-eng level-1	Configure MPLS TE Level-1.
R5(config-router)#mpls traffic-eng level-2	Configure MPLS TE Level-2.
R5(config-router)#isis segment-routing global block 19100 23800	Configure SRGB range (default: 16-23999).
R5(config-router)#segment-routing mpls	Enabling Segment-Routing.
R5(config-router)#net 49.0000.0000.0000.0005.00	Configure net-id.
R5(config-router)#distribute bgp-ls	Distributing BGP-LS.
R5(config-router)#exit	Exit from router isis mode.

R5: BGP

The following are the step-by-step configurations on the R5 router.

R5(config)#router bgp 200	Enter BGP router mode
R5(config)#bgp router-id 5.5.5.5	Configure BGP router-id
R5(config-router)#neighbor 50.1.1.2 remote-as 300	Configure neighbor with remote-as.
R5(config-router)#neighbor 50.1.1.2 update-source lo	Configure neighbor with update-source.
R5(config-router)#address-family link-state link-state	Entering link-state link-state address family.
R5(config-router-af)#neighbor 50.1.1.2 activate	Activating Neighbor in link-state link-state address family.
R5(config-router-af)#exit	Exit from BGP address family mode
R5(config-router)#exit	Exit from bgp router mode

R6: Interface

The following are the step-by-step configurations on the R6 router.

R6#configure terminal	Enter configure mode
R6(config)#hostname R6	Configure hostname
R6(config)#interface lo	Enter interface mode for loopback interface.
R6(config-if)#ip address 6.6.6.6/32 secondary	Configure IPv4 address.
R6(config-if)#ip router isis 1	Configure Router-isis.
R6(config-if)#prefix-sid index 600	Configure Prefix-sid
R6(config-if)#exit	Exit interface mode
R6(config)#interface xe21	Enter interface mode for xe21 interface.
R6(config-if)#ip address 60.1.1.2/24	Configure IPv4 address.
R6(config-if)#label-switching	Enable label switching
R6(config-if)#ip router isis 1	Configure Router-isis.
R6(config-if)#exit	Exit interface mode

R6: ISIS

The following are the step-by-step configurations on the R6 router.

R6(config)#router isis 1	Enter ISIS router mode
R6(config-router)#is-type level-1	Configure IS-type.
R6(config-router)#metric-style wide	Configure Metric-style.
R6(config-router)#mpls traffic-eng router-id 6.6.6.6	Configure MPLS TE router-id.
R6(config-router)#mpls traffic-eng level-1	Configure MPLS TE Level-1.
R6(config-router)#isis segment-routing global block 16100 23990	Configure SRGB range (default: 16-23999).
R6(config-router)#segment-routing mpls	Enabling Segment-Routing.
R6(config-router)#net 49.0000.0000.0000.0006.00	Configure net-id.
R6(config-router)#exit	Exit ISIS router mode

R7 (Controller): Interface

The following are the step-by-step configurations on the R7 router.

R7#configure terminal	Enter configure mode
R7(config)#hostname R7	Configure hostname
R7(config)#in xe4	Entering to interface xe4.
R7(config-if)#ip address 40.1.1.2/24	Configure IPv4 address.

R7(config-if)#in xe8	Entering to interface xe8.
R7(config-if)#ip address 50.1.1.2/24	Configure IPv4 address.
R7(config-if)#exit	Exit interface mode

R7: BGP

The following are the step-by-step configurations on the R7 router.

R7(config-if)#router bgp 300	Entering to router bgp mode.
R7(config-router)#neighbor 40.1.1.1 remote-as 100	Configure neighbor with remote-as.
R7(config-router)#neighbor 40.1.1.1 update-source xe4	Configure neighbor with update-source.
R7(config-router)#neighbor 50.1.1.1 remote-as 200	Configure neighbor with remote-as.
R7(config-router)#neighbor 50.1.1.1 update-source xe8	Configure neighbor with update-source.
R7(config-router)#address-family link-state link-state	Entering link-state link-state address family.
R7(config-router-af)#neighbor 50.1.1.1 activate	Activating Neighbor in link-state link-state address family.
R7(config-router-af)#neighbor 40.1.1.1 activate	Activating Neighbor in link-state link-state address family.
R7(config-router-af)#exit	Exit from BGP address family mode
R7(config-router)#exit	Exit from bgp router mode

Validation on R3

ISIS Neighborhood

Verify ISIS Neighborhood

```
R3#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 1
Total number of adjacencies: 3
Tag 1: VRF : default
System Id      Interface  SNPA                State  Holdtime  Type  Protocol
0000.0000.0001 xe2        e8c5.7a90.cc70      Up     6          L1    IS-IS
0000.0000.0002 xe7        e8c5.7ac5.c2b1      Up     6          L2    IS-IS
0000.0000.0004 xe12       e8c5.7a79.572a      Up     6          L1    IS-IS
```

ISIS Database-Verbose

Verify ISIS Database-Verbose

```
R3#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
0000.0000.0001.00-00 0x0000000C  0x5342        858           0/0/0
```

```

Area Address: 49.0000
NLPID:      0xCC
IP Address:  1.1.1.1
Router ID:   1.1.1.1
Router Cap:  1.1.1.1
  SRGB Range: 3000   SRGB Base SID: 18000   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0001.03
  IPv4 Interface Address: 10.1.1.1
  Neighbor IP Address: 10.1.1.1
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0003   LAN Adjacency SID: 24960   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IP-Extended 1.1.1.1/32
  Prefix-SID: index 100 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 10.11.2.0/30
Metric: 10      IP-Extended 10.1.1.0/24
0000.0000.0001.03-00 0x00000002 0x9335      854      0/0/0
Metric: 0      IS-Extended 0000.0000.0001.00
Metric: 0      IS-Extended 0000.0000.0003.00
0000.0000.0003.00-00* 0x0000000A 0x3E9A      1012     1/0/0
Area Address: 49.0000
NLPID:      0xCC
IP Address:  3.3.3.3
Router ID:   3.3.3.3
Router Cap:  3.3.3.3
  SRGB Range: 4801   SRGB Base SID: 17500   I:1 V:0
  SR-Algorithm:
    Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0004.02
  IPv4 Interface Address: 30.1.1.1
  Neighbor IP Address: 30.1.1.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0004   LAN Adjacency SID: 24320   F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IS-Extended 0000.0000.0001.03
  IPv4 Interface Address: 10.1.1.2
  Neighbor IP Address: 10.1.1.1
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g

```

```

    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    System-ID: 0000.0000.0001 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 3.3.3.3/32
    Prefix-SID: index 300 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 10 IP-Extended 10.1.1.0/24
    Metric: 10 IP-Extended 20.1.1.0/24
    Metric: 10 IP-Extended 30.1.1.0/24
0000.0000.0004.00-00 0x0000000D 0xF8E2 1145 0/0/0
    Area Address: 49.0000
    NLPID: 0xCC
    IP Address: 4.4.4.4
    Router ID: 4.4.4.4
    Router Cap: 4.4.4.4
    SRGB Range: 7301 SRGB Base SID: 16500 I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10 IS-Extended 0000.0000.0004.02
    IPv4 Interface Address: 30.1.1.2
    Neighbor IP Address: 30.1.1.2
    Maximum Link Bandwidth: 10g
    Reservable Bandwidth: 10g
    Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    System-ID: 0000.0000.0003 LAN Adjacency SID: 24960 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 4.4.4.4/32
    Prefix-SID: index 500 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 10 IP-Extended 30.1.1.0/24
0000.0000.0004.02-00 0x00000005 0x9729 854 0/0/0
    Metric: 0 IS-Extended 0000.0000.0004.00
    Metric: 0 IS-Extended 0000.0000.0003.00

IS-IS Level-2 Link State Database:
LSPID LSP Seq Num LSP Checksum LSP Holdtime ATT/P/OL
0000.0000.0002.00-00 0x00000009 0xB85F 929 0/0/0
    Area Address: 49.0001
    NLPID: 0xCC
    IP Address: 2.2.2.2
    Router ID: 2.2.2.2
    Router Cap: 2.2.2.2
    SRGB Range: 3000 SRGB Base SID: 19000 I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10 IS-Extended 0000.0000.0002.02
    IPv4 Interface Address: 20.1.1.1
    Neighbor IP Address: 20.1.1.1
    Maximum Link Bandwidth: 10g
    Reservable Bandwidth: 10g
    Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    System-ID: 0000.0000.0003 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0

```

```

Metric: 10      IP-Extended 2.2.2.2/32
Prefix-SID: index 400 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 20.1.1.0/24
0000.0000.0002.02-00 0x00000002 0x9D28      855      0/0/0
Metric: 0      IS-Extended 0000.0000.0002.00
Metric: 0      IS-Extended 0000.0000.0003.00
0000.0000.0003.00-00* 0x0000000A 0xEBDD      1146      0/0/0
Area Address: 49.0000
NLPID: 0xCC
IP Address: 3.3.3.3
Router ID: 3.3.3.3
Router Cap: 3.3.3.3
SRGB Range: 4801 SRGB Base SID: 17500 I:1 V:0
SR-Algorithm:
Algorithm: 0
Metric: 10      IS-Extended 0000.0000.0002.02
IPv4 Interface Address: 20.1.1.2
Neighbor IP Address: 20.1.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
Unreserved Bandwidth at priority 0: 10g
Unreserved Bandwidth at priority 1: 10g
Unreserved Bandwidth at priority 2: 10g
Unreserved Bandwidth at priority 3: 10g
Unreserved Bandwidth at priority 4: 10g
Unreserved Bandwidth at priority 5: 10g
Unreserved Bandwidth at priority 6: 10g
Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0002 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10      IP-Extended 3.3.3.3/32
Prefix-SID: index 300 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10      IP-Extended 10.1.1.0/24
Metric: 10      IP-Extended 20.1.1.0/24
Metric: 10      IP-Extended 30.1.1.0/24
Metric: 20      IP-Extended 4.4.4.4/32
Prefix-SID: index 500 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20      IP-Extended 1.1.1.1/32
Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20      IP-Extended 10.11.2.0/30

```

BGP Neighborhood

Verify BGP Neighborhood

```

R3#show 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 00:26:06
Last read 00:00:28, 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 Link-State Link-State: advertised and received
Received 77 messages, 0 notifications, 0 in queue
Sent 113 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: Link-State Link-State
BGP table version 21, neighbor version 21
Index 1, Offset 0, Mask 0x2
Community attribute sent to this neighbor (both)
11 accepted prefixes
33 announced prefixes

Connections established 1; dropped 0
Local host: 3.3.3.3, Local port: 44225
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 2.2.2.2, remote AS 100, local AS 100, internal link
BGP version 4, local router ID 3.3.3.3, remote router ID 2.2.2.2
BGP state = Established, up for 00:30:37
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
  Address family Link-State Link-State: advertised and received
Received 115 messages, 0 notifications, 0 in queue
Sent 138 messages, 5 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 2, Offset 0, Mask 0x4
Community attribute sent to this neighbor (both)
0 accepted prefixes
0 announced prefixes

For address family: Link-State Link-State
BGP table version 21, neighbor version 21
Index 2, Offset 0, Mask 0x4
Community attribute sent to this neighbor (both)
20 accepted prefixes
33 announced prefixes

Connections established 3; dropped 2
Local host: 3.3.3.3, Local port: 37071
Foreign host: 2.2.2.2, Foreign port: 179
Nexthop: 3.3.3.3
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:30:42, due to Configuration Change (Cease Notification sent)
Notification Error Message: (Cease/Other Configuration Change.)

BGP neighbor is 40.1.1.2, remote AS 300, local AS 100, external link
BGP version 4, local router ID 3.3.3.3, remote router ID 40.1.1.2
BGP state = Established, up for 00:03:31
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 IPv4 Unicast: advertised and received
  Address family Link-State Link-State: advertised and received
Received 21 messages, 1 notifications, 0 in queue
Sent 51 messages, 1 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 0, Offset 0, Mask 0x1
```

```

Community attribute sent to this neighbor (both)
0 accepted prefixes
0 announced prefixes

For address family: Link-State Link-State
BGP table version 21, neighbor version 21
Index 0, Offset 0, Mask 0x1
Community attribute sent to this neighbor (both)
11 accepted prefixes
53 announced prefixes

Connections established 2; dropped 1
Local host: 40.1.1.1, Local port: 179
Foreign host: 40.1.1.2, Foreign port: 47766
Nexthop: 40.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:03:31, due to Administratively Reset (Cease Notification sent)
Notification Error Message: (Cease/Administratively Reset.)

```

Validation of BGP-LS NLRIs

Verify BGP-LS NLRIs

```

R3#show bgp link-state link-state
BGP router identifier 3.3.3.3, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
i [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]]/208
i [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]]/208
i [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]]/208
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]]/208
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]]/208
e [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
e [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]]/208
e [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]]/208
i [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]]/208
i [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.02]]/208
i [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]]/208
i [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.04]]/208
i [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]]/208
e [V] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
i [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]] [R[c100] [b1.1.1.1] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]]/328
i [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [R[c100] [b1.1.1.1] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]]/328
i [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]] [R[c100] [b1.1.1.1]
[s0000.0000.0001.00]]/264
i [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]] [R[c100] [b1.1.1.1]
[s0000.0000.0003.00]]/264
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]]/328
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]]/328
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3] [s0000.0000.0001.00]]/264

```



```

[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]] /264
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [R[c200] [b5.5.5.5] [s0000.0000.0006.02]]
[L[i60.1.1.1] [n60.1.1.2]] /328
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]] [R[c200] [b5.5.5.5] [s0000.0000.0006.02]]
[L[i60.1.1.2] [n60.1.1.2]] /328
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]] [R[c200] [b5.5.5.5]
[s0000.0000.0005.00]] /264
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]] [R[c200] [b5.5.5.5]
[s0000.0000.0006.00]] /264
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]] [R[c100] [b2.2.2.2] [s0000.0000.0002.02]]
[L[i20.1.1.1] [n20.1.1.1]] /328
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.02]] [R[c100] [b2.2.2.2]
[s0000.0000.0002.00]] /264
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.02]] [R[c100] [b2.2.2.2]
[s0000.0000.0003.00]] /264
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [R[c100] [b2.2.2.2] [s0000.0000.0002.02]]
[L[i20.1.1.2] [n20.1.1.1]] /328
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [R[c100] [b2.2.2.2] [s0000.0000.0003.04]]
[L[i30.1.1.1] [n30.1.1.1]] /328
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.04]] [R[c100] [b2.2.2.2]
[s0000.0000.0003.00]] /264
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.04]] [R[c100] [b2.2.2.2]
[s0000.0000.0004.00]] /264
i [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]] [R[c100] [b2.2.2.2] [s0000.0000.0003.04]]
[L[i30.1.1.2] [n30.1.1.1]] /328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.1] [n20.1.1.1]] /328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3] [s0000.0000.0002.00]] /264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]] /264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.2] [n20.1.1.1]] /328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.1] [n30.1.1.1]] /328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]] /264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3] [s0000.0000.0004.00]] /264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.2] [n30.1.1.1]] /328
i [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]] [P[p10.1.1.0/24]] /240
i [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]] [P[p1.1.1.1/32]] /248
i [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p10.1.1.0/24]] /240
i [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p20.1.1.0/24]] /240
i [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p30.1.1.0/24]] /240
i [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p3.3.3.3/32]] /248
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p10.1.1.0/24]] /240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p1.1.1.1/32]] /248
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]] /240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]] /240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]] /240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]] /248
e [T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p60.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p5.5.5.5/32]] /248
e [T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]] [P[p60.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]] [P[p6.6.6.6/32]] /248
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]] [P[p20.1.1.0/24]] /240
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]] [P[p2.2.2.2/32]] /248
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p10.1.1.0/24]] /240
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p20.1.1.0/24]] /240
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p30.1.1.0/24]] /240
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p1.1.1.1/32]] /248
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p3.3.3.3/32]] /248
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]] [P[p30.1.1.0/24]] /240
i [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]] [P[p4.4.4.4/32]] /248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p20.1.1.0/24]] /240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p2.2.2.2/32]] /248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]] /240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]] /240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]] /240

```

```
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p1.1.1.1/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p30.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p4.4.4.4/32]]/248
e [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p60.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p5.5.5.5/32]]/248
e [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p6.6.6.6/32]]/248
NLRIs, Total: 84, Node: 19, Link: 28, Prefix: 37
```



Note: Count of NLRIs may be different sometimes.

Validation for NLRI count

Verify NLRI count

```
R3#show bgp link-state link-state count
```

```
-----
Total  NLRIs   : 84
Node   NLRIs   : 19
Link   NLRIs   : 28
Prefix NLRIs   : 37
-----
```

Note: Count of NLRIs may be different sometimes.

```
R3#show bgp link-state link-state self-originate
```

```
BGP router identifier 3.3.3.3, local AS number 100
```

```
Origin codes: i - IGP, e - EGP
```

```
Prefix codes: E link, V node, T IP reachable route, I Identifier
```

```
N local node, R remote node, L link, P prefix
```

```
L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
```

```
c confed-ID/ASN, b bgp-identifier, r router-ID,
```

```
i if-address, n nbr-address, o OSPF Route-type,
```

```
p IP-prefix, d designated router address, s ISO-ID
```

```
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]]/208
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]]/208
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]]/328
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]]/328
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3] [s0000.0000.0001.00]]/264
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.1] [n20.1.1.1]]/328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3] [s0000.0000.0002.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.2] [n20.1.1.1]]/328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.1] [n30.1.1.1]]/328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3] [s0000.0000.0004.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.2] [n30.1.1.1]]/328
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p10.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p1.1.1.1/32]]/248
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]]/240
```

```
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p20.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p2.2.2.2/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p1.1.1.1/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p30.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p4.4.4.4/32]]/248
NLRIs, Total: 34, Node: 7, Link: 12, Prefix: 15
```



Note: Count of NLRIs may be different sometimes.

Validation for Node-NLRI

Verify Node-NLRI

```
R3#show bgp link-state link-state [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
BGP routing table entry for [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
Local
  Received from 40.1.1.2
  Link State:
  Aux Router ID: 5.5.5.5
  ISIS area address:49.0000
  Range Size: 4701 Base SID: 19100 SR Algorithm: 0 SR Flags: I:1 V:0
  Node flag bits: O:0 T:0 B:0 E:0
```

Validation for Link-NLRI

Verify Link-NLRI

```
R3#show bgp link-state link-state [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [R[c200]
[b5.5.5.5]
[s0000.0000.0006.02]] [L[i60.1.1.1] [n60.1.1.2]]/328
BGP routing table entry for [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [R[c200]
[b5.5.5.5]
[s0000.0000.0006.02]] [L[i60.1.1.1] [n60.1.1.2]]/328
Local
  Received from 40.1.1.2
  Link State:
  Local Router ID: 5.5.5.5, Admin-group: Max link bw: 3124999936.00 ,Max reservable link bw:
3124999936.00
  Max unreserved link bw:3124999936.00 3124999936.00 3124999936.00 3124999936.00 3124999936.00
3124999936.00 3124999936.00 3124999936.00
  TE metric 10 , IGP metric 10
  SR Flags: F:0 B:0 V:1 L:1 S:0 P:0
  MT-ID: 0 Neighbor ID: 0000.0000.0006 LAN Adjacency SID: 24320
```

Validation for Prefix-NLRI

Verify Prefix-NLRI

```
R3#show bgp link-state link-state [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P
[p5.5.5.5/32]]/248
BGP routing table entry for [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P
[p5.5.5.5/32]]/248
Local
  Received from 40.1.1.2
  Link State:
  Metric: 10 SID: 19300 SR Flags: R:0 N:1 P:0 E:0 V:1 L:0
```

Validation on R5

ISIS Neighbor ship

Verify ISIS Neighbor ship

```
R5#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
0000.0000.0006 xe21      e8c5.7ad2.5ec3      Up     7         L1    IS-IS
```

ISIS Database Verbose

Verify ISIS Database Verbose

```
R5#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
0000.0000.0005.00-00* 0x00000005   0x9107        1003          0/0/0
  Area Address: 49.0000
  NLPID:        0xCC
  IP Address:   60.1.1.1
  Router ID:    5.5.5.5
  Router Cap:   5.5.5.5
    SRGB Range: 4701   SRGB Base SID: 19100  I:1 V:0
    SR-Algorithm:
      Algorithm: 0
  Metric: 10          IS-Extended 0000.0000.0006.01
    IPv4 Interface Address: 60.1.1.1
    Neighbor IP Address: 60.1.1.2
    Maximum Link Bandwidth: 10g
    Reservable Bandwidth: 10g
    Unreserved Bandwidth:
      Unreserved Bandwidth at priority 0: 10g
      Unreserved Bandwidth at priority 1: 10g
      Unreserved Bandwidth at priority 2: 10g
      Unreserved Bandwidth at priority 3: 10g
      Unreserved Bandwidth at priority 4: 10g
      Unreserved Bandwidth at priority 5: 10g
      Unreserved Bandwidth at priority 6: 10g
      Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    System-ID: 0000.0000.0006 LAN Adjacency SID: 26880  F:0 B:0 V:1 L:1 S:0 P:0
  Metric: 10          IP-Extended 60.1.1.0/24
  Metric: 10          IP-Extended 5.5.5.5/32
    Prefix-SID: index 700 R:0 N:1 P:0 E:0 V:0 L:0
  Metric: 10          IP-Extended 10.0.1.33/32
0000.0000.0006.00-00 0x00000002   0xE6B7        938          0/0/0
  Area Address: 49.0000
  NLPID:        0xCC
  IP Address:   60.1.1.2
  Router ID:    6.6.6.6
  Router Cap:   6.6.6.6
    SRGB Range: 7891   SRGB Base SID: 16100  I:1 V:0
    SR-Algorithm:
      Algorithm: 0
  Metric: 10          IS-Extended 0000.0000.0006.01
    IPv4 Interface Address: 60.1.1.2
    Neighbor IP Address: 60.1.1.2
    Maximum Link Bandwidth: 10g
    Reservable Bandwidth: 10g
```

```

Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0005 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 60.1.1.0/24
Metric: 10 IP-Extended 6.6.6.6/32
Prefix-SID: index 600 R:0 N:1 P:0 E:0 V:0 L:0
0000.0000.0006.01-00 0x00000001 0xD0EE 934 0/0/0
Metric: 0 IS-Extended 0000.0000.0006.00
Metric: 0 IS-Extended 0000.0000.0005.00

IS-IS Level-2 Link State Database:
LSPID LSP Seq Num LSP Checksum LSP Holddtime ATT/P/OL
0000.0000.0005.00-00* 0x00000006 0xB9A2 1003 0/0/0
Area Address: 49.0000
NLPID: 0xCC
IP Address: 60.1.1.1
Router ID: 5.5.5.5
Router Cap: 5.5.5.5
SRGB Range: 4701 SRGB Base SID: 19100 I:1 V:0
SR-Algorithm:
Algorithm: 0
Metric: 10 IP-Extended 60.1.1.0/24
Metric: 10 IP-Extended 5.5.5.5/32
Prefix-SID: index 700 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 10 IP-Extended 10.0.1.33/32
Metric: 20 IP-Extended 6.6.6.6/32
Prefix-SID: index 600 R:1 N:0 P:0 E:0 V:0 L:0

```

Validation of BGP-LS NLRIs

Verify BGP-LS NLRIs

```

R5#sho bgp link-state link-state
BGP router identifier 5.5.5.5, local AS number 200
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
e [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]]/208
e [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]]/208
e [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]]/208
e [V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]]/208
e [V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
e [V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]]/208
[V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
[V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]]/208
[V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.02]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.04]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]]/208
e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]]/208
e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]]/208

```

```

e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] /208
[V] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] /208
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]] [R[c100] [b1.1.1.1] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]] /328
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [R[c100] [b1.1.1.1] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]] /328
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]] [R[c100] [b1.1.1.1]
[s0000.0000.0001.00]] /264
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]] [R[c100] [b1.1.1.1]
[s0000.0000.0003.00]] /264
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]] /328
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]] /328
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3]
[s0000.0000.0001.00]] /264
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3]
[s0000.0000.0003.00]] /264
[E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [R[c200] [b5.5.5.5] [s0000.0000.0006.02]]
[L[i60.1.1.1] [n60.1.1.2]] /328
[E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]] [R[c200] [b5.5.5.5] [s0000.0000.0006.02]]
[L[i60.1.1.2] [n60.1.1.2]] /328
[E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]] [R[c200] [b5.5.5.5] [s0000.0000.0005.00]] /264
[E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]] [R[c200] [b5.5.5.5] [s0000.0000.0006.00]] /264
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]] [R[c100] [b2.2.2.2] [s0000.0000.0002.02]]
[L[i20.1.1.1] [n20.1.1.1]] /328
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.02]] [R[c100] [b2.2.2.2]
[s0000.0000.0002.00]] /264
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.02]] [R[c100] [b2.2.2.2]
[s0000.0000.0003.00]] /264
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [R[c100] [b2.2.2.2] [s0000.0000.0002.02]]
[L[i20.1.1.2] [n20.1.1.1]] /328
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [R[c100] [b2.2.2.2] [s0000.0000.0003.04]]
[L[i30.1.1.1] [n30.1.1.1]] /328
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.04]] [R[c100] [b2.2.2.2]
[s0000.0000.0003.00]] /264
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.04]] [R[c100] [b2.2.2.2]
[s0000.0000.0004.00]] /264
e [E] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]] [R[c100] [b2.2.2.2] [s0000.0000.0003.04]]
[L[i30.1.1.2] [n30.1.1.1]] /328
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.1] [n20.1.1.1]] /328
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3]
[s0000.0000.0002.00]] /264
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3]
[s0000.0000.0003.00]] /264
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.2] [n20.1.1.1]] /328
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.1] [n30.1.1.1]] /328
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3]
[s0000.0000.0003.00]] /264
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3]
[s0000.0000.0004.00]] /264
e [E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.2] [n30.1.1.1]] /328
e [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]] [P[p10.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]] [P[p1.1.1.1/32]] /248
e [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p10.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p20.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p30.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [P[p3.3.3.3/32]] /248
e [T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p10.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p1.1.1.1/32]] /248
e [T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]] /240
e [T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]] /248

```

```

[T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p60.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p5.5.5.5/32]]/248
[T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]] [P[p60.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]] [P[p6.6.6.6/32]]/248
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]] [P[p20.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]] [P[p2.2.2.2/32]]/248
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p10.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p20.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p30.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p1.1.1.1/32]]/248
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]] [P[p3.3.3.3/32]]/248
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]] [P[p30.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]] [P[p4.4.4.4/32]]/248
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p20.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p2.2.2.2/32]]/248
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p1.1.1.1/32]]/248
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]]/248
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p30.1.1.0/24]]/240
e [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p4.4.4.4/32]]/248
[T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p60.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p5.5.5.5/32]]/248
[T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P[p6.6.6.6/32]]/248
NLRIs, Total: 84, Node: 19, Link: 28, Prefix: 37

```



Note: Count of NLRIs may be different sometimes.

Validation for NLRI Count

Verify NLRI Count

```

R5#sho bgp link-state link-state count
-----
Total   NLRIs   : 100
Node    NLRIs   : 24
Link    NLRIs   : 32
Prefix NLRIs   : 44
-----

```



Note: Count of NLRIs may be different sometimes.

Verify NLRI Self-originate

```

R5#show bgp link-state link-state self-originate
BGP router identifier 5.5.5.5, local AS number 200
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
[V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
[V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]]/208
[V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]]/208
[V] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208

```

```
[E][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][R[c200][b5.5.5.5][s0000.0000.0006.02]][L
[i60.1.1.1][n60.1.1.2]]/328
[E][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0006.00]][R[c200][b5.5.5.5][s0000.0000.0006.02]][L
[i60.1.1.2][n60.1.1.2]]/328
[E][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0006.02]][R[c200][b5.5.5.5][s0000.0000.0005.00]]/264
[E][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0006.02]][R[c200][b5.5.5.5][s0000.0000.0006.00]]/264
[T][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p60.1.1.0/24]]/240
[T][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p5.5.5.5/32]]/248
[T][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0006.00]][P[p60.1.1.0/24]]/240
[T][L1][I0x1][N[c200][b5.5.5.5][s0000.0000.0006.00]][P[p6.6.6.6/32]]/248
[T][L2][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p60.1.1.0/24]]/240
[T][L2][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p5.5.5.5/32]]/248
[T][L2][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p6.6.6.6/32]]/248
NLRIs, Total: 15, Node: 4, Link: 4, Prefix: 7
Note:      Count of NLRIs may be different sometimes.
```

Validation for Node-NLRI

Verify Node-NLRI

```
R5#show bgp link-state link-state [V][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0001.00]]/208
BGP routing table entry for [V][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0001.00]]/208
Local
  Received from 50.1.1.2
  Link State:
  Aux Router ID: 1.1.1.1
  ISIS area address:49.0002
  Range Size: 8000   Base SID: 16000   SR Algorithm: 0   SR Flags: I:1 V:0
  Node flag bits: O:0 T:0 B:0 E:0
```

Validation for Link-NLRI

Verify Link-NLRI

```
R5#show bgp link-state link-state [E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0001.00]][R[c100]
[b1.1.1.1]
[s0000.0000.0003.02]][L[i10.1.1.1][n10.1.1.2]]/328
BGP routing table entry for [E][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0001.00]][R[c100]
[b1.1.1.1]
[s0000.0000.0003.02]][L[i10.1.1.1][n10.1.1.2]]/328
Local
  Received from 50.1.1.2
  Link State:
  Local Router ID: 1.1.1.1, Admin-group:   Max link bw: 1250000000.00 ,Max reservable link bw:
1250000000.00
  Max unreserved link bw:1250000000.00 1250000000.00 1250000000.00 1250000000.00 1250000000.00
1250000000.00 1250000000.00 1250000000.00
  TE metric 10 ,   IGP metric 10
  SR Flags: F:0 B:0 V:1 L:1 S:0 P:0
  MT-ID: 0 Neighbor ID: 0000.0000.0003 LAN Adjacency SID: 24320
```

Validation for Prefix-NLRI

Verify Prefix-NLRI

```
R5#show bgp link-state link-state [T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0001.00]][P
[p1.1.1.1/32]]/248
BGP routing table entry for [T][L1][I0x1][N[c100][b1.1.1.1][s0000.0000.0001.00]][P
[p1.1.1.1/32]]/248
Local
  Received from 50.1.1.2
  Link State:
  Metric: 10      SID: 16100   SR Flags: R:0 N:1 P:0 E:0 V:1 L:0
```


Validation on Controller

BGP Neighborhood

Verify BGP Neighborhood

```
Controller#show bgp neighbors
BGP neighbor is 40.1.1.1, remote AS 100, local AS 300, external link
  BGP version 4, local router ID 40.1.1.2, remote router ID 3.3.3.3
  BGP state = Established, up for 00:21:40
  Last read 00:00:07, 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 Link-State Link-State: advertised and received
  Received 124 messages, 0 notifications, 0 in queue
  Sent 71 messages, 1 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
  0 announced prefixes

For address family: Link-State Link-State
  BGP table version 7, neighbor version 7
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  69 accepted prefixes
  15 announced prefixes

Connections established 2; dropped 1
Local host: 40.1.1.2, Local port: 47766
Foreign host: 40.1.1.1, Foreign port: 179
Nexthop: 40.1.1.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
Last Reset: 00:21:45, due to Configuration Change (Cease Notification sent)
Notification Error Message: (Cease/Other Configuration Change.)

BGP neighbor is 50.1.1.1, remote AS 200, local AS 300, external link
  BGP version 4, local router ID 40.1.1.2, remote router ID 5.5.5.5
  BGP state = Established, up for 00:21:35
  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 Link-State Link-State: advertised and received
  Received 79 messages, 0 notifications, 0 in queue
  Sent 94 messages, 1 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 2, Offset 0, Mask 0x4
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  0 announced prefixes

For address family: Link-State Link-State
  BGP table version 7, neighbor version 7
  Index 0, Offset 0, Mask 0x1
  Community attribute sent to this neighbor (both)
  15 accepted prefixes
```

```

69 announced prefixes

Connections established 2; dropped 1
Local host: 50.1.1.2, Local port: 179
Foreign host: 50.1.1.1, Foreign port: 43896
Nextthop: 50.1.1.2
Nextthop global: ::
Nextthop local: ::
BGP connection: non shared network
Last Reset: 00:21:40, due to Configuration Change (Cease Notification sent)
Notification Error Message: (Cease/Other Configuration Change.)

```

Validation of BGP-LS NLRIs

Verify BGP-LS NLRIs

```

Controller#show bgp link-state link-state
BGP router identifier 40.1.1.2, local AS number 300
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
e [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]]/208
e [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]]/208
e [V] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]]/208
e [V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]]/208
e [V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
e [V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]]/208
e [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
e [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]]/208
e [V] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.00]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0002.02]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.00]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0003.04]]/208
e [V] [L2] [I0x1] [N[c100] [b2.2.2.2] [s0000.0000.0004.00]]/208
e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]]/208
e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]]/208
e [V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]]/208
e [V] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]]/208
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0001.00]] [R[c100] [b1.1.1.1] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]]/328
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.00]] [R[c100] [b1.1.1.1] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]]/328
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]] [R[c100] [b1.1.1.1]
[s0000.0000.0001.00]]/264
e [E] [L1] [I0x1] [N[c100] [b1.1.1.1] [s0000.0000.0003.02]] [R[c100] [b1.1.1.1]
[s0000.0000.0003.00]]/264
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]]/328
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]]/328
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3]
[s0000.0000.0001.00]]/264
e [E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3]
[s0000.0000.0003.00]]/264
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [R[c200] [b5.5.5.5] [s0000.0000.0006.02]]
[L[i60.1.1.1] [n60.1.1.2]]/328
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.00]] [R[c200] [b5.5.5.5] [s0000.0000.0006.02]]
[L[i60.1.1.2] [n60.1.1.2]]/328
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]] [R[c200] [b5.5.5.5]
[s0000.0000.0005.00]]/264
e [E] [L1] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0006.02]] [R[c200] [b5.5.5.5]

```

[illegible]

```
e [T][L2][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p60.1.1.0/24]]/240
e [T][L2][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p5.5.5.5/32]]/248
e [T][L2][I0x1][N[c200][b5.5.5.5][s0000.0000.0005.00]][P[p6.6.6.6/32]]/248
NLRIs, Total: 84, Node: 19, Link: 28, Prefix: 37
```



Note: Count of NLRIs may be different sometimes.

Validation for Particular NLRI

Verify Particular NLRI

```
Controller#show bgp link-state link-state [V][L2][I0x1][N[c100][b2.2.2.2]
[s0000.0000.0002.00]]/208
BGP routing table entry for [V][L2][I0x1][N[c100][b2.2.2.2][s0000.0000.0002.00]]/208
Local
  Received from 40.1.1.1
  Link State:
  Aux Router ID: 2.2.2.2
  ISIS area address:49.0001
  Range Size: 8000 Base SID: 16000 SR Algorithm: 0 SR Flags: I:1 V:0
  Node flag bits: O:0 T:0 B:0 E:0

Controller#show bgp link-state link-state [E][L2][I0x1][N[c100][b2.2.2.2][s0000.0000.0004.00]][R
[c100][b2.2.2.2]
[s0000.0000.0003.04]][L[i30.1.1.2][n30.1.1.1]]/328
BGP routing table entry for [E][L2][I0x1][N[c100][b2.2.2.2][s0000.0000.0004.00]][R[c100]
[b2.2.2.2]
[s0000.0000.0003.04]][L[i30.1.1.2][n30.1.1.1]]/328
Local
  Received from 40.1.1.1
  Link State:
  Local Router ID: 4.4.4.4, Admin-group: Max link bw: 1250000000.00 ,Max reservable link bw:
1250000000.00
  Max unreserved link bw:1250000000.00 1250000000.00 1250000000.00 1250000000.00 1250000000.00
1250000000.00 1250000000.00 1250000000.00
  TE metric 10 , IGP metric 10
  SR Flags: F:0 B:0 V:1 L:1 S:0 P:0
  MT-ID: 0 Neighbor ID: 0000.0000.0003 LAN Adjacency SID: 24320

Controller#show bgp link-state link-state [T][L2][I0x1][N[c100][b3.3.3.3][s0000.0000.0004.00]]
[P[p4.4.4.4/32]]/248
BGP routing table entry for [T][L2][I0x1][N[c100][b3.3.3.3][s0000.0000.0004.00]][P
[p4.4.4.4/32]]/248
Local
  Received from 40.1.1.1
  Link State:
  Metric: 10 SID: 16700 SR Flags: R:0 N:1 P:0 E:0 V:1 L:0
```

SRMS Configuration

Configuration

R5

The following are the step-by-step configurations on the R5 router.

R5(config)#segment-routing	Entering to SRMS.
R5(config-sr)#mapping-server	Entering to Mapping Server
R5(config-sr-ms)#prefix-sid-map address-family ipv4	Entering to prefix-to sid mapping.
R5(config-sr-ms-map-af4)#21.21.21.21/32 4545 attached	Configure SID for prefix.
R5(config-sr-ms-map-af4)#31.31.31.31/32 3535 attached	Configure SID for prefix.
R5(config-sr-ms-map-af4)#end	Exit from SRMS.
R5#configure terminal	Entering to Config mode.
R5(config)#router isis 1	Entering to router isis mode.
R5(config-router)#segment-routing prefix-sid-map advertise-local	Configure advertise-local for prefix-sid mapping.
R5(config-router)#exit	Exit from router isis mode

R3

The following are the step-by-step configurations on the R3 router.

R3(config)#segment-routing	Entering to SRMS.
R3(config-sr)#mapping-server	Entering to Mapping Server
R3(config-sr-ms)#prefix-sid-map address-family ipv4	Entering to prefix-to sid mapping.
R3(config-sr-ms-map-af4)#11.11.11.11/32 1111 range 3	Configure SID for prefix.
R3(config-sr-ms-map-af4)#12.12.12.12/32 6767 range 1	Configure SID for prefix.
R3(config-sr-ms-map-af4)#end	Exit from SRMS.
R3#configure terminal	Entering to Config mode.
R3(config)#router isis 1	Entering to router isis mode.
R3(config-router)#segment-routing prefix-sid-map advertise-local	Configure advertise-local for prefix-sid mapping.
R3(config-router)#exit	Exit from router isis mode

Validation on R3

ISIS Database Verbose

Validation

Verify ISIS Database Verbose

```
R3#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
R1.00-00              0x00000018  0xBFF4       1071          0/0/0
  Area Address: 49.0000
  NLPID: 0xCC
  Hostname: R1
  IP Address: 10.1.1.1
  Router ID: 1.1.1.1
  Router Cap: 1.1.1.1
    SRGB Range: 3000   SRGB Base SID: 18000   I:1 V:0
    SR-Algorithm:
      Algorithm: 0
  Metric: 10          IS-Extended R1.01
  IPv4 Interface Address: 10.1.1.1
  Neighbor IP Address: 10.1.1.1
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0003 LAN Adjacency SID: 24960 F:0 B:0 V:1 L:1 S:0 P:0
  Metric: 10          IP-Extended 10.1.1.0/30
  Metric: 10          IP-Extended 1.1.1.1/32
  Prefix-SID: index 100 R:0 N:1 P:0 E:0 V:0 L:0
R1.01-00              0x00000002  0xA129       1083          0/0/0
  Metric: 0           IS-Extended R1.00
  Metric: 0           IS-Extended R3.00
R1.02-00              0x00000012  0xC623       0 (328)        0/0/0
R3.00-00              * 0x00000116  0x5AAC       1194          1/0/0
  Area Address: 49.0000
  NLPID: 0xCC
  Hostname: R3
  IP Address: 10.1.1.2
  Router ID: 3.3.3.3
  Router Cap: 3.3.3.3
    SRGB Range: 4801   SRGB Base SID: 17500   I:1 V:0
    SR-Algorithm:
      Algorithm: 0
    SRMS-Preference: 128
  Metric: 10          IS-Extended R1.01
  IPv4 Interface Address: 10.1.1.2
  Neighbor IP Address: 10.1.1.1
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
  TE-Default Metric: 10
  System-ID: 0000.0000.0001 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
  Metric: 10          IS-Extended 0000.0000.0004.01
  IPv4 Interface Address: 30.1.1.1
  Neighbor IP Address: 30.1.1.2
  Maximum Link Bandwidth: 10g
  Reservable Bandwidth: 10g
  Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g

```

```

    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    System-ID: 0000.0000.0004 LAN Adjacency SID: 24322 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 10.1.1.0/24
    Metric: 10 IP-Extended 20.1.1.0/24
    Metric: 10 IP-Extended 30.1.1.0/24
    Metric: 10 IP-Extended 3.3.3.3/32
    Prefix-SID: index 300 R:0 N:1 P:0 E:0 V:0 L:0
    Metric: 20 IP-Extended 2.2.2.2/32
    Prefix-SID: index 400 R:1 N:0 P:0 E:0 V:0 L:0
    SID Binding: 11.11.11.11/32 F:0 M:0 S:0 D:0 A:0 Range:3
    SID: Start:1111 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
    SID Binding: 12.12.12.12/32 F:0 M:0 S:0 D:0 A:0 Range:1
    SID: Start:6767 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
0000.0000.0004.00-00 0x00000016 0xAA99 1071 0/0/0
    Area Address: 49.0000
    NLPID: 0xCC
    IP Address: 30.1.1.2
    Router ID: 4.4.4.4
    Router Cap: 4.4.4.4
    SRGB Range: 7301 SRGB Base SID: 16500 I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10 IS-Extended 0000.0000.0004.01
    IPv4 Interface Address: 30.1.1.2
    Neighbor IP Address: 30.1.1.2
    Maximum Link Bandwidth: 10g
    Reservable Bandwidth: 10g
    Unreserved Bandwidth:
    Unreserved Bandwidth at priority 0: 10g
    Unreserved Bandwidth at priority 1: 10g
    Unreserved Bandwidth at priority 2: 10g
    Unreserved Bandwidth at priority 3: 10g
    Unreserved Bandwidth at priority 4: 10g
    Unreserved Bandwidth at priority 5: 10g
    Unreserved Bandwidth at priority 6: 10g
    Unreserved Bandwidth at priority 7: 10g
    TE-Default Metric: 10
    System-ID: 0000.0000.0003 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
    Metric: 10 IP-Extended 30.1.1.0/24
    Metric: 10 IP-Extended 4.4.4.4/32
    Prefix-SID: index 500 R:0 N:1 P:0 E:0 V:0 L:0
0000.0000.0004.01-00 0x00000001 0xA61F 395 0/0/0
    Metric: 0 IS-Extended 0000.0000.0004.00
    Metric: 0 IS-Extended R3.00
0000.0000.0004.02-00 0x00000010 0xB236 0 (365) 0/0/0

IS-IS Level-2 Link State Database:
LSPID LSP Seq Num LSP Checksum LSP Holdtime ATT/P/OL
0000.0000.0002.00-00 0x0000001A 0xD622 1071 0/0/0
    Area Address: 49.0001
    NLPID: 0xCC
    IP Address: 20.1.1.1
    Router ID: 2.2.2.2
    Router Cap: 2.2.2.2
    SRGB Range: 3000 SRGB Base SID: 19000 I:1 V:0
    SR-Algorithm:
    Algorithm: 0
    Metric: 10 IS-Extended 0000.0000.0002.01
    IPv4 Interface Address: 20.1.1.1
    Neighbor IP Address: 20.1.1.1
    Maximum Link Bandwidth: 10g

```

```

Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0003 LAN Adjacency SID: 24320 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 20.1.1.0/24
Metric: 10 IP-Extended 2.2.2.2/32
Prefix-SID: index 400 R:0 N:1 P:0 E:0 V:0 L:0
0000.0000.0002.01-00 0x00000002 0xA422 1191 0/0/0
Metric: 0 IS-Extended 0000.0000.0002.00
Metric: 0 IS-Extended R3.00
0000.0000.0002.03-00 0x00000013 0xB72D 0 (256) 0/0/0
R3.00-00 * 0x00000127 0x0123 1185 0/0/0
Area Address: 49.0000
NLPID: 0xCC
Hostname: R3
IP Address: 10.1.1.2
Router ID: 3.3.3.3
Router Cap: 3.3.3.3
SRGB Range: 4801 SRGB Base SID: 17500 I:1 V:0
SR-Algorithm:
  Algorithm: 0
SRMS-Preference: 128
Metric: 10 IS-Extended 0000.0000.0002.01
IPv4 Interface Address: 20.1.1.2
Neighbor IP Address: 20.1.1.1
Maximum Link Bandwidth: 10g
Reservable Bandwidth: 10g
Unreserved Bandwidth:
  Unreserved Bandwidth at priority 0: 10g
  Unreserved Bandwidth at priority 1: 10g
  Unreserved Bandwidth at priority 2: 10g
  Unreserved Bandwidth at priority 3: 10g
  Unreserved Bandwidth at priority 4: 10g
  Unreserved Bandwidth at priority 5: 10g
  Unreserved Bandwidth at priority 6: 10g
  Unreserved Bandwidth at priority 7: 10g
TE-Default Metric: 10
System-ID: 0000.0000.0002 LAN Adjacency SID: 24321 F:0 B:0 V:1 L:1 S:0 P:0
Metric: 10 IP-Extended 10.1.1.0/24
Metric: 10 IP-Extended 20.1.1.0/24
Metric: 20 IP-Extended 10.1.1.0/30
Metric: 10 IP-Extended 30.1.1.0/24
Metric: 10 IP-Extended 3.3.3.3/32
Prefix-SID: index 300 R:0 N:1 P:0 E:0 V:0 L:0
Metric: 20 IP-Extended 1.1.1.1/32
Prefix-SID: index 100 R:1 N:0 P:0 E:0 V:0 L:0
Metric: 20 IP-Extended 4.4.4.4/32
Prefix-SID: index 500 R:1 N:0 P:0 E:0 V:0 L:0
SID Binding: 11.11.11.11/32 F:0 M:0 S:0 D:0 A:0 Range:3
SID: Start:1111 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0
SID Binding: 12.12.12.12/32 F:0 M:0 S:0 D:0 A:0 Range:1
SID: Start:6767 Algorithm:0 R:0 N:0 P:0 E:0 V:0 L:0

```

Validation for NLRI count

Verify NLRI count

```
R3#sho bgp link-state link-state count
```



```

-----
Total   NLRIs   : 96
Node    NLRIs   : 19
Link    NLRIs   : 28
Prefix  NLRIs   : 49
-----

```



Note: Count of NLRIs may be different sometimes.

Verify NLRI Self-originate

```

R3#sho bgp link-state link-state self-originate
BGP router identifier 3.3.3.3, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]]/208
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
[V] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]]/208
[V] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]]/208
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.1] [n10.1.1.2]]/328
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.02]]
[L[i10.1.1.2] [n10.1.1.2]]/328
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3] [s0000.0000.0001.00]]/264
[E] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.02]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.1] [n20.1.1.1]]/328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3] [s0000.0000.0002.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.02]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0002.02]]
[L[i20.1.1.2] [n20.1.1.1]]/328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.1] [n30.1.1.1]]/328
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3] [s0000.0000.0003.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.04]] [R[c100] [b3.3.3.3] [s0000.0000.0004.00]]/264
[E] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [R[c100] [b3.3.3.3] [s0000.0000.0003.04]]
[L[i30.1.1.2] [n30.1.1.1]]/328
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p10.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0001.00]] [P[p1.1.1.1/32]]/248
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]]/240
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]]/248
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p11.11.11.11/32]]/248
[T] [L1] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p12.12.12.12/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p20.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0002.00]] [P[p2.2.2.2/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p10.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p20.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p30.1.1.0/24]]/240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p1.1.1.1/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p3.3.3.3/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p11.11.11.11/32]]/248
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p12.12.12.12/32]]/248

```

```
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p30.1.1.0/24]] /240
[T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0004.00]] [P[p4.4.4.4/32]] /248
NLRIs, Total: 38, Node: 7, Link: 12, Prefix: 19
```

**Notes:**

- Count of NLRIs may be different sometimes.
- Here the total number of NLRI increases because of prefixes configured in SRMS.

Validation for Particular NLRI

Verify the prefix-NLRIs for prefixes configured in SRMS.

```
R3#show bgp link-state link-state [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P
[p11.11.11.11/32]] /248
BGP routing table entry for [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P
[p11.11.11.11/32]] /248
Local
  Received from IGP
  Link State:
  SRMS SID: Start: 1111 Range: 3 Algorithm: 0 SR Flags: F:0 M:0 S:0 D:0 A:0
  SR Flags: R:0 N:0 P:0 E:0 V:0 L:0

R3#show bgp li li [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P[p12.12.12.12/32]] /248
BGP routing table entry for [T] [L2] [I0x1] [N[c100] [b3.3.3.3] [s0000.0000.0003.00]] [P
[p12.12.12.12/32]] /248
Local
  Received from IGP
  Link State:
  SRMS SID: Start: 6767 Range: 1 Algorithm: 0 SR Flags: F:0 M:0 S:0 D:0 A:0
  SR Flags: R:0 N:0 P:0 E:0 V:0 L:0

R3#show bgp link-state link-state [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P
[p21.21.21.21/32]] /248
BGP routing table entry for [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P
[p21.21.21.21/32]] /248
Local
  Received from 40.1.1.2
  Link State:
  SRMS SID: Start: 4545 Range: 1 Algorithm: 0 SR Flags: F:0 M:0 S:0 D:0 A:1
  SR Flags: R:0 N:0 P:0 E:0 V:0 L:0

R3#show bgp link-state link-state [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P
[p31.31.31.31/32]] /248
BGP routing table entry for [T] [L2] [I0x1] [N[c200] [b5.5.5.5] [s0000.0000.0005.00]] [P
[p31.31.31.31/32]] /248
Local
  Received from 40.1.1.2
  Link State:
  SRMS SID: Start: 3535 Range: 1 Algorithm: 0 SR Flags: F:0 M:0 S:0 D:0 A:1
  SR Flags: R:0 N:0 P:0 E:0 V:0 L:0
```

BGP Link State with OSPF Segment Routing

This section contains configuration and validation of BGP-Link state extension for OSPF-SR.

Overview

Segment Routing (SR) allows a headend node to steer a packet flow along any path. Intermediate per-flow states are eliminated due to source routing. The headend node is said to steer a flow into a Segment Routing Policy (SR Policy). The header of a packet steered in an SR Policy is augmented with the ordered list of segments associated with that SR Policy. This feature is supported for the MPLS instantiations.

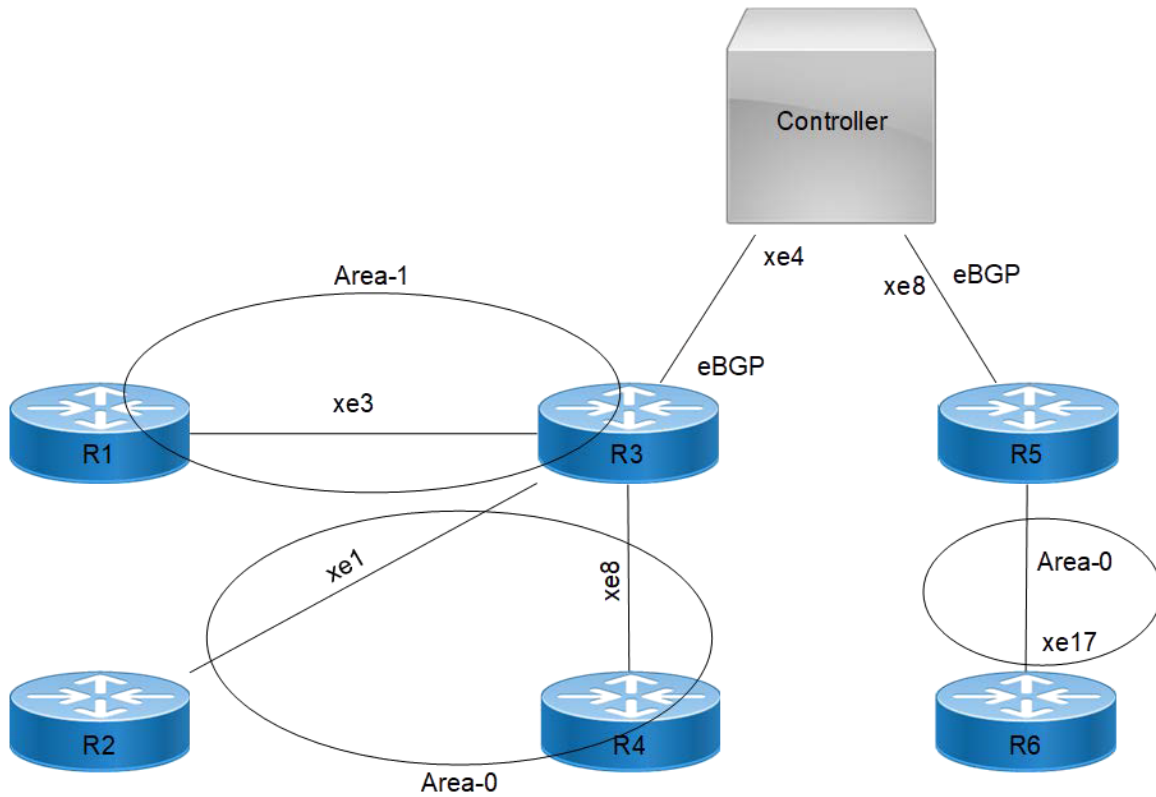
BGP-LS describes a mechanism by which Link-State (LS) and Traffic Engineering (TE) information from IGPs can be collected from networks and shared with external components using the BGP. This is achieved using a new BGP Network Layer Reachability Information (NLRI) encoding format. These components, while external to the network, require network state information on a real time basis. Specifically, they require link-state database information of each IGP node from the entire network. BGP protocol is used to collect the necessary information and to share with the external components and this is achieved using a NLRI encoding format.

A new NLRI is defined in order to advertise SR Policy to the headend of that policy. New sub-TLVs for the Tunnel Encapsulation Attribute are defined to carry SR related information.

Topology

Here we have taken 7 nodes out of which 6 nodes are OSPF-SR enabled routers and node 7 will act as controller. R3 belong to autonomous-system-100 and R5 belong to autonomous-system-200. R1's xe3 and R3's xe3 belong to Area-1. R2, R4 and R3 belong to Area-0 . R5 and R6 belong to Area-0 . We shall configure OSPF-SR on every node. We shall give distribute-BGP-LS on R3 and R5, after that we will make an E- BGP session between R3 and Controller and R5 and controller. Under link-state link-state address family we will activate the neighbors. Verification will be done on ASBRS which are R3 and R5.

All NLRIs (Node, Link and Prefix) should display proper SR information of nodes belong to other AS.

Figure 53. BGP link state with OSPF segment routing

OSPF Segment Routing Configuration

Configuration

R1

The following are the step-by-step configurations on the R1 router.

R1#configure terminal	Entering to config mode
R1(config)# hostname R1	Configure hostname
R1(config)#interface lo	Going to interface mode for loopback interface.
R1(config-if)#ip address 1.1.1.1/32 secondary	Configure IPv4 address.
R1(config-if)#prefix-sid absolute 18001	Configure Prefix-sid absolute
R1(config-if)#exit	Exit from interface mode.
R1(config)#interface xe3	Going to interface mode for xe3 interface.
R1(config-if)#ip address 10.1.1.1/24	Configure IPv4 address.

R1(config-if)# label-switching	Configure Label-Switching.
R1(config-if)#exit	Exit from interface mode.
R1(config)# router ospf 100	Entering router ospf.
R1(config-router)# ospf router-id 1.1.1.1	Configure OSPF router-id.
R1(config-router)# network 1.1.1.1/32 area 0.0.0.1	Configure network.
R1(config-router)# network 10.1.1.0/24 area 0.0.0.1	Configure network.
R1(config-router)# segment-routing mpls	Configure segment-routing MPLS.
R1(config-router)#exit	Exit from router-ospf mode.

R2

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Entering to config mode
R2(config)# hostname R2	Configure hostname
R2(config)#interface lo	Going to interface mode for loopback interface.
R2(config-if)#ip address 2.2.2.2/32 secondary	Configure IPv4 address.
R2(config-if)#prefix-sid absolute 18002	Configure Prefix-sid
R2(config-if)#exit	Exit from interface mode.
R2(config)# interface xe1	Going to interface mode for xe1 interface.
R2(config-if)#ip address 11.1.1.1/24	Configure IPv4 address.
R2(config-if)# label-switching	Configure Label-Switching.
R2(config-if)#exit	Exit from interface mode.
R2(config)#router ospf 100	Entering router ospf.
R2(config-router)# ospf router-id 2.2.2.2	Configure OSPF Router-id.
R2(config-router)# network 2.2.2.2/32 area 0.0.0.0	Configure Network.
R2(config-router)# network 11.1.1.0/24 area 0.0.0.0	Configure Network.
R2(config-router)# segment-routing mpls	Configure segment-routing MPLS.
R2(config-router)#exit	Exit from router-ospf mode.

R3

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Entering to config mode
-----------------------	-------------------------

R3(config)# hostname R3	Configure hostname
R3(config)#interface lo	Going to interface mode for loopback interface.
R3(config-if)#ip address 3.3.3.3/32 secondary	Configure IPv4 address.
R1(config-if)#prefix-sid absolute 18003	Configure Prefix-sid
R3(config-if)#exit	Exit from interface mode.
R3(config)#interface xe3	Going to interface mode for xe3 interface.
R3(config-if)#ip address 10.1.1.2/24	Configure IPv4 address.
R3(config-if)# label-switching	Configure Label-Switching.
R3(config-if)#exit	Exit from interface mode.
R3(config)#interface xe1	Going to interface mode for xe1 interface.
R3(config-if)#ip address 11.1.1.2/24	Configure IPv4 address.
R3(config-if)# label-switching	Configure Label-Switching.
R3(config-if)#exit	Exit from interface mode.
R3(config)#interface xe8	Going to interface mode for xe8 interface.
R3(config-if)#ip address 12.1.1.2/24	Configure IPv4 address.
R3(config-if)# label-switching	Configure Label-Switching
R3(config-if)#exit	Exit from interface mode.
R3(config)#interface xe4	Going to interface mode for xe4 interface.
R3(config-if)#ip address 13.1.1.1/24	Configure IPv4 address.
R3(config-if)#exit	Exit from interface mode.
R3(config)# router ospf 100	Entering router ospf.
R3(config-router)# ospf router-id 3.3.3.3	Configure OSPF Router-ID.
R3(config-router)# distribute bgp-ls	Configure Distribute BGP-LS.
R3(config-router)# network 3.3.3.3/32 area 0.0.0.0	Configure Network.
R3(config-router)# network 10.1.1.0/24 area 0.0.0.1	Configure Network.
R3(config-router)# network 11.1.1.0/24 area 0.0.0.0	Configure Network.
R3(config-router)# network 12.1.1.0/24 area 0.0.0.0	Configure Network
R3(config-router)# segment-routing mpls	Configure segment-routing MPLS.
R3(config-router)#exit	Exit from router-ospf mode.
R3(config)#router bgp 100	Entering router bgp.
R3(config)# bgp router-id 3.3.3.3	Configure BGP router-id
R3(config-router)# neighbor 13.1.1.2 remote-as 300	Configure E-BGP neighbor with remote-as.
R3(config-router)# address-family link-state link-state	Configure link-state link-state address-family.

R3(config-router-af)# neighbor 13.1.1.2 activate	Activating controller's interface address as neighbor in link-state link-state address family.
R3(config-router-af)#exit	Exit from router bgp-address-family mode
R3(config-router)#exit	Exit from router bgp mode

R4

The following are the step-by-step configurations on the R4 router.

R4#configure terminal	Entering to config mode
R4(config)# hostname R4	Configure hostname
R4(config)#interface lo	Going to interface mode for loopback interface.
R4(config-if)#ip address 4.4.4.4/32 secondary	Configure IPv4 address.
R4(config-if)#prefix-sid absolute 18004	Configure Prefix-sid
R4(config-if)#exit	Exit from interface mode.
R4(config)#interface xe8	Going to interface mode for xe8 interface.
R4(config-if)#ip address 12.1.1.1/24	Configure IPv4 address.
R4(config-if)# label-switching	Configure Label-Switching.
R4(config-if)#exit	Exit from interface mode.
R4(config)#router ospf 100	Entering router ospf.
R4(config-router)# ospf router-id 4.4.4.4	Configure OSPF Router-ID.
R4(config-router)# network 4.4.4.4/32 area 0.0.0.0	Configure network.
R4(config-router)# network 12.1.1.0/24 area 0.0.0.0	Configure network.
R4(config-router)#segment-routing mpls	Enabling Segment-Routing.
R4(config-router)#exit	Exit from router-ospf mode.

R5

The following are the step-by-step configurations on the R5 router.

R5#configure terminal	Entering to config mode
R5(config)# hostname R5	Configure hostname
R5(config)#interface lo	Going to interface mode for loopback interface.
R5(config-if)#ip address 5.5.5.5/32 secondary	Configure IPv4 address.
R4(config-if)#prefix-sid absolute 18005	Configure Prefix-sid
R5(config-if)#exit	Exit from interface mode.
R5(config)#interface xe17	Going to interface mode for xe17 interface.

R5(config-if)#ip address 15.1.1.1/24	Configure IPv4 address.
R5(config-if)# label-switching	Configure Label-Switching.
R5(config-if)#exit	Exit from interface mode.
R5(config)#interface xe8	Going to interface mode for xe8 interface.
R5(config-if)#ip address 14.1.1.1/24	Configure IPv4 address.
R5(config-if)#exit	Exit from interface mode.
R5(config)# router ospf 100	Entering router OSPF.
R5(config-router)# ospf router-id 5.5.5.5	Configure OSPF router-id.
R5(config-router)# distribute bgp-ls	Distributing BGP-LS.
R5(config-router)# network 5.5.5.5/32 area 0.0.0.0	Configure network.
R5(config-router)# network 15.1.1.0/24 area 0.0.0.0	Configure network.
R5(config-router)# segment-routing mpls	Enabling Segment-Routing.
R5(config-router)#exit	Exit from router-ospf mode.
R5(config)#router bgp 200	Entering router bgp.
R5(config)# bgp router-id 5.5.5.5	Configure BGP router-id
R5(config-router)# neighbor 14.1.1.2 remote-as 300	Configure E-BGP neighbor with remote-as.
R5(config-router)#address-family link-state link-state	Entering link-state link-state address family.
R5(config-router-af)# neighbor 14.1.1.2 activate	Activating controller's interface address as neighbor in link-state link-state address family.
R5(config-router-af)#exit	Exit from router bgp-address-family mode.
R5(config-router)#exit	Exit from router bgp mode.

R6

The following are the step-by-step configurations on the R6 router.

R6#configure terminal	Entering to config mode
R6(config)# hostname R6	Configure hostname
R6(config)#interface lo	Going to interface mode for loopback interface.
R6(config-if)#ip address 6.6.6.6/32 secondary	Configure IPv4 address.
R6(config-if)#prefix-sid absolute 18006	Configure Prefix-sid
R6(config-if)#exit	Exit from interface mode.
R6(config)#interface xe17	Going to interface mode for xe17 interface.
R6(config-if)#ip address 15.1.1.2/24	Configure IPv4 address.
R6(config-if)# label-switching	Configure Label-Switching.

R6(config-if)#exit	Exit from interface mode.
R6(config)# router ospf 100	Entering router OSPF.
R6(config-router)# ospf router-id 6.6.6.6	Configure OSPF Router-id.
R6(config-router)# network 6.6.6.6/32 area 0.0.0.0	Configure network.
R6(config-router)# network 15.1.1.0/24 area 0.0.0.0	Configure network.
R6(config-router)#segment-routing mpls	Enabling Segment-Routing.
R6(config-router)#exit	Exit from router-ospf mode.

Controller (R7)

The following are the step-by-step configurations on the controller.

Controller#configure terminal	Entering to config mode
Controller(config)# hostname Controller	Configure hostname
Controller(config)#in eth1	Entering to interface eth1.
Controller(config-if)#ip address 13.1.1.2/24	Configure IPv4 address.
Controller(config-if)#in eth2	Entering to interface eth2.
Controller(config-if)#ip address 14.1.1.2/24	Configure IPv4 address.
Controller(config-if)#exit	Exit from interface mode.
Controller(config-if)#router bgp 300	Entering to router bgp mode.
Controller(config-router)# neighbor 13.1.1.1 remote-as 100	Configure neighbor with remote-as.
Controller(config-router)# neighbor 14.1.1.1 remote-as 200	Configure neighbor with remote-as.
Controller(config-router)#address-family link-state link-state	Entering link-state link-state address family.
Controller(config-router-af)# neighbor 13.1.1.1 activate	Activating R3's interface address as neighbor in link-state link-state address family.
Controller(config-router-af)# neighbor 14.1.1.1 activate	Activating R5's interface address as neighbor in link-state link-state address family.
Controller(config-router-af)#exit	Exit from bgp address-family mode
Controller(config-router)#exit	Exit from router bgp mode.

Validation

R3

Validation of R3 router

```
R3#show ip ospf neighbor
```

Total number of full neighbors: 3

OSPF process 100 VRF(default):

Neighbor ID	Pri	State	Dead Time	Address	Interface
1.1.1.1	1	Full/DR	00:00:36	10.1.1.1	xe3 0
2.2.2.2	1	Full/DR	00:00:37	11.1.1.1	xe1 0
4.4.4.4	1	Full/Backup	00:00:37	12.1.1.1	xe8 0

R3#show ip ospf database opaque-ar

OSPF Router with ID (3.3.3.3) (Process ID 100 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 1726
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 1
 Advertising Router: 2.2.2.2
 LS Seq Number: 80000002
 Checksum: 0x32eb
 Length: 28

MPLS TE router ID : 2.2.2.2

Number of Links : 0

LS age: 1483
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 1
 Advertising Router: 3.3.3.3
 LS Seq Number: 80000002
 Checksum: 0x36df
 Length: 28

MPLS TE router ID : 3.3.3.3

Number of Links : 0

LS age: 366
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 1
 Advertising Router: 4.4.4.4
 LS Seq Number: 80000002
 Checksum: 0x3ad3
 Length: 28

MPLS TE router ID : 4.4.4.4

Number of Links : 0

LS age: 90
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 22
 Advertising Router: 2.2.2.2

LS Seq Number: 80000002
Checksum: 0xb784
Length: 108

Link connected to Broadcast network

Link ID : 11.1.1.1
Interface Address : 11.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 253
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 22
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0xb77f
Length: 108

Link connected to Broadcast network

Link ID : 11.1.1.1
Interface Address : 11.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 153
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0x9792
Length: 108

Link connected to Broadcast network

Link ID : 12.1.1.2
Interface Address : 12.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

```
Number of Links : 1

LS age: 86
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 32
Advertising Router: 4.4.4.4
LS Seq Number: 80000002
Checksum: 0x5bcb
Length: 108

Link connected to Broadcast network
Link ID : 12.1.1.2
Interface Address : 12.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1947
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 2.2.2.2
LS Seq Number: 80000001
Checksum: 0xd702
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm0: 0

LS age: 1719
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0xb91c
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm0: 0

LS age: 1477
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 4.4.4.4
```

```
LS Seq Number: 80000001
Checksum: 0x9b36
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm0: 0

LS age: 1947
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 2.2.2.2
LS Seq Number: 80000001
Checksum: 0x9d50
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 2.2.2.2
Flags: 0x08 (-|-|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18002

LS age: 1719
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0x0a5c
Length: 68

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 3.3.3.3
Flags: 0x08 (-|-|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18003

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-|-)
Address Prefix: 1.1.1.1
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18001

LS age: 86
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
```

```
Opaque Type: 7
Opaque ID: 0
Advertising Router: 4.4.4.4
LS Seq Number: 80000002
Checksum: 0xf7e2
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 4.4.4.4
Flags: 0x08 (-|-|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18004

LS age: 1726
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 2.2.2.2
LS Seq Number: 80000001
Checksum: 0x5860
Length: 52

Link Type: 2
Link ID: 11.1.1.1
Link Data: 11.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 3.3.3.3
SID: 24320

LS age: 1719
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0x08c3
Length: 48

Link Type: 2
Link ID: 11.1.1.1
Link Data: 11.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24321

LS age: 1483
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0xf6ae
Length: 52
```

```

Link Type: 2
Link ID: 12.1.1.2
Link Data: 12.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
NBR ID: 4.4.4.4
SID: 24322

```

```

LS age: 1477
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 4.4.4.4
LS Seq Number: 80000001
Checksum: 0xb011
Length: 48

```

```

Link Type: 2
Link ID: 12.1.1.2
Link Data: 12.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24320

```

Area-Local Opaque-LSA (Area 0.0.0.1)

```

LS age: 1726
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 1.1.1.1
LS Seq Number: 80000002
Checksum: 0x2ef7
Length: 28

```

MPLS TE router ID : 1.1.1.1

Number of Links : 0

```

LS age: 433
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0x36df
Length: 28

```

MPLS TE router ID : 3.3.3.3

Number of Links : 0

```

LS age: 430
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 1.1.1.1

```

LS Seq Number: 80000002
Checksum: 0x0c40
Length: 108

Link connected to Broadcast network

Link ID : 10.1.1.1
Interface Address : 10.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 283
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0xed55
Length: 108

Link connected to Broadcast network

Link ID : 10.1.1.1
Interface Address : 10.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 610
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 1.1.1.1
LS Seq Number: 80000002
Checksum: 0xf3e8
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm0: 0

LS age: 33
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 3.3.3.3


```
LS Seq Number: 80000002
Checksum: 0xb71d
Length: 44

Range Size: 8000
Base-SID: 16000
Algorithm0: 0

LS age: 2140
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.1
LS Seq Number: 80000001
Checksum: 0x6f87
Length: 44

Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 1.1.1.1
Flags: 0x08 (-|-|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18001

LS age: 1474
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0x6fe0
Length: 92

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0xc0 (A|N|-|-|-|-|-)
Address Prefix: 3.3.3.3
Flags: 0x08 (-|-|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18003

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 2.2.2.2
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18002

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
```

```

Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 4.4.4.4
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18004

```

```

LS age: 380
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 1.1.1.1
LS Seq Number: 80000002
Checksum: 0x8c36
Length: 52

```

```

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 3.3.3.3
SID: 24320

```

```

LS age: 1719
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0x03d0
Length: 48

```

```

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

```

R3#

R3#show ip bgp neighbors

BGP neighbor is 13.1.1.2, remote AS 300, local AS 100, external link BGP version 4, local router ID 3.3.3.3, remote router ID 40.1.1.2 BGP state = Established, up for 00:05:16

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 Link-State Link-State: advertised and received

Received 22 messages, 0 notifications, 0 in queue

Sent 38 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

0 announced prefixes

For address family: Link-State Link-State BGP table version 5, neighbor version 5 Index 1, Offset 0, Mask 0x2

Community attribute sent to this neighbor (both)

9 accepted prefixes

31 announced prefixes

Connections established 1; dropped 0
 Local host: 13.1.1.1, Local port: 45926
 Foreign host: 13.1.1.2, Foreign port: 179
 Nexthop: 13.1.1.1 Nexthop global: ::
 Nexthop local: ::
 BGP connection: non shared network

R3#show bgp link-state link-state

BGP router identifier 3.3.3.3, local AS number 100 Origin codes: i - IGP, e - EGP
 Prefix codes: E link, V node, T IP reachable route, I Identifier N local node, R remote node, L link, P prefix
 L1/L2 ISIS level-1/level-2, O OSPF, a area-ID, c confed-ID/ASN, b bgp-identifier, r router-ID, i if-address, n nbr-address, o OSPF Route-type,
 p IP-prefix, d designated router address, s ISO-ID [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2]]/216
 [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1]]/248
 [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]/216
 [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2]]/248
 [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]]/216
 [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1]]/216
 [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1]]/248
 [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]/216
 e [V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]]/216
 e [V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1]]/248
 e [V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6]]/216
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2][R[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1]]][L[i11.1.1.1][n11.1.1.1]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1][R[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2]]][L[i11.1.1.1][n11.1.1.1]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][L[i11.1.1.1][n11.1.1.2]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1]]][L[i11.1.1.1][n11.1.1.2]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2]]][L[i12.1.1.2][n12.1.1.2]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][L[i12.1.1.2][n12.1.1.2]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2][R[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]]][L[i12.1.1.2][n12.1.1.1]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2]]][L[i12.1.1.1][n12.1.1.2]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1][R[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1]]][L[i10.1.1.1][n10.1.1.1]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1][R[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1]]][L[i10.1.1.1][n10.1.1.1]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1][R[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][L[i10.1.1.1][n10.1.1.2]]/376
 [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1]]][L[i10.1.1.2][n10.1.1.1]]/376
 e [E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5][R[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1]]][L[i15.1.1.1][n15.1.1.1]]/376
 e [E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1][R[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]]][L[i15.1.1.1][n15.1.1.1]]/376
 e [E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1][R[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6]]][L[i15.1.1.1][n15.1.1.2]]/376
 e [E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6][R[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1]]][L[i15.1.1.2][n15.1.1.1]]/376
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2]]][P[0x1][p2.2.2.2/32]]/264
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][P[0x1][p3.3.3.3/32]]/264
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][P[0x2][p10.1.1.0/24]]/256
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][P[0x2][p1.1.1.1/32]]/264
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]]][P[0x1][p4.4.4.4/32]]/264
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1]]][P[0x1][p1.1.1.1/32]]/264
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][P[0x2][p11.1.1.0/24]]/256
 [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][P[0x2][p12.1.1.0/24]]/256

```

[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p2.2.2.2/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p3.3.3.3/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p4.4.4.4/32]]/264
e [T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]][P[0x1][p5.5.5.5/32]]/264
e [T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6]][P[0x1][p6.6.6.6/32]]/264
NLRIs, Total: 40, Node: 11, Link: 16, Prefix: 13
Note: Count of NLRIs may be different sometimes.
R3#show bgp link-state link-state count

```

```

Total   NLRIs   :   40
Node    NLRIs   :   11
Link    NLRIs   :   16
Prefix  NLRIs   :   13

```

```

R3#show bgp link-state link-state self-originate BGP router identifier 3.3.3.3, local AS number
100 Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier N local node, R remote node, L
link, P prefix
L1/L2 ISIS level-1/level-2, O OSPF, a area-ID, c confed-ID/ASN, b bgp-identifier, r router-ID, i
if-address, n nbr-address, o OSPF Route-type,
p IP-prefix, d designated router address, s ISO-ID [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0]
[r2.2.2.2]]/216
[V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2d11.1.1.1]]/248
[V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]/216
[V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3d12.1.1.2]]/248
[V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]]/216
[V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1]]/216
[V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1d10.1.1.1]]/248
[V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]/216
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2][R[c100][b3.3.3.3][a0.0.0.0][r2.2.2.
2d11.1.1.1]]][L[i11.1.1.1][n11.1.1.1]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2d11.1.1.1][R[c100][b3.3.3.3][a0.0.0.0]
[r2.2.2.2]]][L[i11.1.1.1][n11.1.1.1]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2d11.1.1.1][R[c100][b3.3.3.3][a0.0.0.0]
[r3.3.3.3]]][L[i11.1.1.1][n11.1.1.2]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.0][r2.2.2.
2d11.1.1.1]]][L[i11.1.1.2][n11.1.1.1]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.
3d12.1.1.2]]][L[i12.1.1.2][n12.1.1.2]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3d12.1.1.2][R[c100][b3.3.3.3][a0.0.0.0]
[r3.3.3.3]]][L[i12.1.1.2][n12.1.1.2]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3d12.1.1.2][R[c100][b3.3.3.3][a0.0.0.0]
[r4.4.4.4]]][L[i12.1.1.2][n12.1.1.1]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][a0.0.0.0][r4.4.4.4][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.
3d12.1.1.2]]][L[i12.1.1.1][n12.1.1.2]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1][R[c100][b3.3.3.3][a0.0.0.1][r1.1.1.
1d10.1.1.1]]][L[i10.1.1.1][n10.1.1.1]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1d10.1.1.1][R[c100][b3.3.3.3][a0.0.0.1]
[r1.1.1.1]]][L[i10.1.1.1][n10.1.1.1]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1d10.1.1.1][R[c100][b3.3.3.3][a0.0.0.1]
[r3.3.3.3]]][L[i10.1.1.1][n10.1.1.2]]/376
[E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.1][r1.1.1.
1d10.1.1.1]]][L[i10.1.1.2][n10.1.1.1]]/376
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2]][P[0x1][p2.2.2.2/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]][P[0x1][p3.3.3.3/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]][P[0x2][p10.1.1.0/24]]/256
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]][P[0x2][p1.1.1.1/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]][P[0x1][p4.4.4.4/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1]][P[0x1][p1.1.1.1/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p11.1.1.0/24]]/256
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p12.1.1.0/24]]/256
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p2.2.2.2/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p3.3.3.3/32]]/264
[T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]][P[0x2][p4.4.4.4/32]]/264

NLRIs, Total: 31, Node: 8, Link: 12, Prefix: 11
Note: Count of NLRIs may be different sometimes.

```

Node-NLRI

```
R3#show bgp link-state link-state [V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]]/ 216
BGP routing table entry for [V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]]/216 Local
Received from 13.1.1.2 Link State:
Range Size: 8000 Base SID: 16000 SR Algorithm: 0 Node flag bits: O:0 T:0 B:0 E:0
Local TE Router-ID:5.5.5.5
```

Link-NLRI

```
R3#show bgp link-state link-state [E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6][R[c200]
[b5.5.5.5][a0.0.0.0][r5.5.5.5. 5d15.1.1.1]][L[i15.1.1.2][n15.1.1.1]]/376
BGP routing table entry for [E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6][R[c200][b5.5.5.5]
[a0.0.0.0][r5.5.5.5. 5d15.1.1.1]][L[i15.1.1.2][n15.1.1.1]]/376
Local
Received from 13.1.1.2
Link State:
Local Router ID: 6.6.6.6, Remote Router ID: 5.5.5.5
Max link bw(kbits/sec): 10000000.00 ,Max reservable link bw(kbits/sec): 10000000.00
Max unreserved link bw(kbits/sec):10000000.00 10000000.00 10000000.00 10000000.00 10000000.00
10000000.00 10000000.00 10000000.00
TE metric 1 , IGP metric 1
SR Flags: B:0 V:1 L:1 G:0 P:0
Adjacency SID: 24320
Local TE Router-ID:6.6.6.6
```

Prefix-NLRI

Validation of R3 Prefix-NLRI

```
R3#show bgp link-state link-state [T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]][P[0x1]
[p5.5.5.5/32]]/264
BGP routing table entry for [T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]][P[0x1]
[p5.5.5.5/32]]/264
Local
Received from 13.1.1.2
Link State:
Prefix flag bits:64[N]
Metric: 1 SID: 18005 SR Flags: NP:0 M:0 E:0 V:1 L:0
Source Router ID:5.5.5.5
Local TE Router-ID:5.5.5.5
```

R5

Validation of R5 router

```
R5#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

6.6.6.6 1 Full/Backup 00:00:37 15.1.1.2 xe17 0

R5#show ip ospf database opaque-area

OSPF Router with ID (5.5.5.5) (Process ID 100 VRF default) Area-Local Opaque-LSA (Area 0.0.0.0)
LS age: 914
Options: 0x22 (-|-|DC|-|-|E|-) LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID) Opaque Type: 1
Opaque ID: 1
Advertising Router: 5.5.5.5 LS Seq Number: 80000002 Checksum: 0x3ec7
```

Length: 28

MPLS TE router ID : 5.5.5.5

Number of Links : 0 LS age: 915

Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID) Opaque Type: 1

Opaque ID: 1

Advertising Router: 6.6.6.6 LS Seq Number: 80000001 Checksum: 0x44ba

Length: 28

MPLS TE router ID : 6.6.6.6

Number of Links : 0 LS age: 914

Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.42 (Area-Local Opaque-Type/ID) Opaque Type: 1

Opaque ID: 42

Advertising Router: 5.5.5.5 LS Seq Number: 80000001 Checksum: 0x1f87

Length: 108

Link connected to Broadcast network

Link ID : 15.1.1.1

Interface Address : 15.1.1.1 Admin Metric : 1

Maximum bandwidth : 25000000.00 Kbits/s

Maximum reservable bandwidth : 25000000.00 Kbits/s Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 25000000.00 Kbits/s Priority 1 : 25000000.00 Kbits/s

Priority 2 : 25000000.00 Kbits/s Priority 3 : 25000000.00 Kbits/s

Priority 4 : 25000000.00 Kbits/s Priority 5 : 25000000.00 Kbits/s

Priority 6 : 25000000.00 Kbits/s Priority 7 : 25000000.00 Kbits/s Number of Links : 1

LS age: 915

Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA

Link State ID: 1.0.0.42 (Area-Local Opaque-Type/ID) Opaque Type: 1

Opaque ID: 42

Advertising Router: 6.6.6.6 LS Seq Number: 80000001 Checksum: 0x1f82

Length: 108

Link connected to Broadcast network Link ID : 15.1.1.1

Interface Address : 15.1.1.2 Admin Metric : 1

Maximum bandwidth : 25000000.00 Kbits/s

Maximum reservable bandwidth : 25000000.00 Kbits/s Unreserved Bandwidth :

Number of Priority : 8

Priority 0 : 25000000.00 Kbits/s Priority 1 : 25000000.00 Kbits/s

Priority 2 : 25000000.00 Kbits/s Priority 3 : 25000000.00 Kbits/s

Priority 4 : 25000000.00 Kbits/s Priority 5 : 25000000.00 Kbits/s

Priority 6 : 25000000.00 Kbits/s Priority 7 : 25000000.00 Kbits/s Number of Links : 1

LS age: 1069

Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID) Opaque Type: 4

Opaque ID: 0

Advertising Router: 5.5.5.5 LS Seq Number: 80000001 Checksum: 0x7d50

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm: 0

LS age: 912

Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA

Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID) Opaque Type: 4

Opaque ID: 0

Advertising Router: 6.6.6.6 LS Seq Number: 80000001 Checksum: 0x5f6a

Length: 44

Range Size: 8000

Base-SID: 16000

Algorithm: 0

```

LS age: 1069
Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID) Opaque Type: 7
Opaque ID: 0
Advertising Router: 5.5.5.5 LS Seq Number: 80000001 Checksum: 0x28aa
Length: 44

```

```

Prefix type : Extended Prefix TLV Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-) Address Prefix: 5.5.5.5
Flags: 0x08 (-|-|-|-|V|-|-|-) MT-ID: 0
Algorithm: 0
SID: 18005

```

```

LS age: 912
Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID) Opaque Type: 7
Opaque ID: 0

Advertising Router: 6.6.6.6 LS Seq Number: 80000001 Checksum: 0x5673
Length: 44

```

```

Prefix type : Extended Prefix TLV Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-) Address Prefix: 6.6.6.6
Flags: 0x08 (-|-|-|-|V|-|-|-) MT-ID: 0
Algorithm: 0
SID: 18006

```

```

LS age: 914
Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.35 (Area-Local Opaque-Type/ID) Opaque Type: 8
Opaque ID: 10019
Advertising Router: 5.5.5.5 LS Seq Number: 80000001 Checksum: 0x5935
Length: 52

```

```

Link Type: 2
Link ID: 15.1.1.1
Link Data: 15.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-) MT-ID: 0
NBR ID: 6.6.6.6
SID: 24320

```

```

LS age: 912
Options: 0x22 (-|-|DC|-|-|-|E|-) LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.35 (Area-Local Opaque-Type/ID) Opaque Type: 8
Opaque ID: 10019
Advertising Router: 6.6.6.6 LS Seq Number: 80000001 Checksum: 0x941a
Length: 48

```

```

Link Type: 2
Link ID: 15.1.1.1

Link Data: 15.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-) MT-ID: 0
SID: 24320

```

```

R5#show bgp link-state link-state
BGP router identifier 5.5.5.5, local AS number 200 Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier N local node, R remote node, L
link, P prefix
L1/L2 ISIS level-1/level-2, O OSPF, a area-ID, c confed-ID/ASN, b bgp-identifier, r router-ID, i
if-address, n nbr-address, o OSPF Route-type,

```

```

p IP-prefix, d designated router address, s ISO-ID e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0]
[r2.2.2.2]]/216
e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1]]/248
e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]/216
e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2]]/248
e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]]/216
e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1]]/216
e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1]]/248
e [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]/216
[V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]]/216
[V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1]]/248
[V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6]]/216
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2][R[c100][b3.3.3.3][a0.0.0.0][r2.2.2.
2d11.1.1.1]]][L[i11.1.1.1][n11.1.1.1]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1][R[c100][b3.3.3.3][a0.0.0.0
][r2.2.2.2]]][L[i11.1.1.1][n11.1.1.1]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2d11.1.1.1][R[c100][b3.3.3.3][a0.0.0.0
][r3.3.3.3]]][L[i11.1.1.1][n11.1.1.2]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.0][r2.2.2.
2d11.1.1.1]]][L[i11.1.1.2][n11.1.1.1]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.
3d12.1.1.2]]][L[i12.1.1.2][n12.1.1.2]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2][R[c100][b3.3.3.3][a0.0.0.0
][r3.3.3.3]]][L[i12.1.1.2][n12.1.1.2]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3d12.1.1.2][R[c100][b3.3.3.3][a0.0.0.0
][r4.4.4.4]]][L[i12.1.1.2][n12.1.1.1]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4][R[c100][b3.3.3.3][a0.0.0.0][r3.3.3.
3d12.1.1.2]]][L[i12.1.1.1][n12.1.1.2]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1][R[c100][b3.3.3.3][a0.0.0.1][r1.1.1.
1d10.1.1.1]]][L[i10.1.1.1][n10.1.1.1]]/376

e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1][R[c100][b3.3.3.3][a0.0.0.1
][r1.1.1.1]]][L[i10.1.1.1][n10.1.1.1]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1d10.1.1.1][R[c100][b3.3.3.3][a0.0.0.1
][r3.3.3.3]]][L[i10.1.1.1][n10.1.1.2]]/376
e [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3][R[c100][b3.3.3.3][a0.0.0.1][r1.1.1.
1d10.1.1.1]]][L[i10.1.1.2][n10.1.1.1]]/376
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5][R[c200][b5.5.5.5][a0.0.0.0][r5.5.5.
5d15.1.1.1]]][L[i15.1.1.1][n15.1.1.1]]/376
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1][R[c200][b5.5.5.5][a0.0.0.0
][r5.5.5.5]]][L[i15.1.1.1][n15.1.1.1]]/376
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1][R[c200][b5.5.5.5][a0.0.0.0
][r6.6.6.6]]][L[i15.1.1.1][n15.1.1.2]]/376
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6][R[c200][b5.5.5.5][a0.0.0.0][r5.5.5.
5d15.1.1.1]]][L[i15.1.1.2][n15.1.1.1]]/376
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2]]][P[0x1][p2.2.2.2/32]]/264
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][P[0x1][p3.3.3.3/32]]/264
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][P[0x2][p10.1.1.0/24]]/256
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3]]][P[0x2][p1.1.1.1/32]]/264
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]]][P[0x1][p4.4.4.4/32]]/264
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r1.1.1.1]]][P[0x1][p1.1.1.1/32]]/264
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][P[0x2][p11.1.1.0/24]]/256
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][P[0x2][p12.1.1.0/24]]/256
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][P[0x2][p2.2.2.2/32]]/264
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][P[0x2][p3.3.3.3/32]]/264
e [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.1][r3.3.3.3]]][P[0x2][p4.4.4.4/32]]/264
[T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]]][P[0x1][p5.5.5.5/32]]/264
[T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6]]][P[0x1][p6.6.6.6/32]]/264
NLRIs, Total: 40, Node: 11, Link: 16, Prefix: 13
Note: Count of NLRIs may be different sometimes.
R5#show bgp link-state link-state count

Total   NLRIs    :   40
Node    NLRIs    :   11
Link    NLRIs    :   16
Prefix  NLRIs    :   13
Note:    Count of NLRIs may be different sometimes.
R5#show bgp link-state link-state self-originate BGP router identifier 5.5.5.5, local AS number

```



```

200 Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier N local node, R remote node, L
link, P prefix
L1/L2 ISIS level-1/level-2, O OSPF, a area-ID, c confed-ID/ASN, b bgp-identifier, r router-ID, i
if-address, n nbr-address, o OSPF Route-type,
p IP-prefix, d designated router address, s ISO-ID [V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0]
[r5.5.5.5]]/216
[V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1]]/248

[V][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6]]/216
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5][R[c200][b5.5.5.5][a0.0.0.0][r5.5.5.
5d15.1.1.1]]][L[i15.1.1.1][n15.1.1.1]]/376
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1][R[c200][b5.5.5.5][a0.0.0.0
][r5.5.5.5]]][L[i15.1.1.1][n15.1.1.1]]/376
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5d15.1.1.1][R[c200][b5.5.5.5][a0.0.0.0
][r6.6.6.6]]][L[i15.1.1.1][n15.1.1.2]]/376
[E][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6][R[c200][b5.5.5.5][a0.0.0.0][r5.5.5.
5d15.1.1.1]]][L[i15.1.1.2][n15.1.1.1]]/376
[T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r5.5.5.5]]][P[0x1][p5.5.5.5/32]]/264
[T][O][I0x64][N[c200][b5.5.5.5][a0.0.0.0][r6.6.6.6]]][P[0x1][p6.6.6.6/32]]/264
NLRI's, Total: 9, Node: 3, Link: 4, Prefix: 2

```



Note: Count of NLRIs may be different sometimes.

Validation for Particular NLRI

Node-NLRI

Validation for R5 Node-NLRI

```

R5#show bgp link-state link-state [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2]]/ 216
BGP routing table entry for [V][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r2.2.2.2]]/216 Local
Received from 14.1.1.2 Link State:
Range Size: 8000 Base SID: 16000 SR Algorithm: 0 Node flag bits: O:0 T:0 B:0 E:0
Local TE Router-ID:2.2.2.2

```

Link-NLRI

Validation for R5 Link-NLRI

```

R5#show bgp li li [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100][b3.3.3.3]
[a0.0.0.0][r2.2.2. 2d11.1.1.1]]][L[i11.1.1.2][n11.1.1.1]]/376
BGP routing table entry for [E][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r3.3.3.3][R[c100]
[b3.3.3.3][a0.0.0.0][r2.2.2. 2d11.1.1.1]]][L[i11.1.1.2][n11.1.1.1]]/376
Local
Received from 14.1.1.2
Link State:
Local Router ID: 3.3.3.3, Remote Router ID: 2.2.2.2
Max link bw(kbits/sec): 10000000.00 ,Max reservable link bw(kbits/sec): 10000000.00
Max unreserved link bw(kbits/sec):10000000.00 10000000.00 10000000.00 10000000.00 10000000.00
10000000.00 10000000.00 10000000.00
TE metric 1 , IGP metric 1
SR Flags: B:0 V:1 L:1 G:0 P:0
Adjacency SID: 24321
Local TE Router-ID:3.3.3.3

```

Prefix-NLRI

Validation for R5 Prefix-NLRI

```
R5#show bgp link-state link-state [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]][P[0x1]
[p4.4.4.4/32]]/264
BGP routing table entry for [T][O][I0x64][N[c100][b3.3.3.3][a0.0.0.0][r4.4.4.4]][P[0x1]
[p4.4.4.4/32]]/264

Local
  Received from 13.1.1.2
  Link State:
  Prefix flag bits:64[N]
  Metric: 1      SID: 18005  SR Flags: NP:0 M:0 E:0 V:1 L:0
  Source Router ID:5.5.5.5
  Local TE Router-ID:5.5.5.5
```

Controller (R7)

Validation for Controller (R7)

```
Controller#show bgp neighbors
BGP neighbor is 13.1.1.1, remote AS 100, local AS 300, external link
  BGP version 4, local router ID 40.1.1.2, remote router ID 3.3.3.3
  BGP state = Established, up for 00:16:41
  Last read 00:00:12, 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 Link-State Link-State: advertised and received
  Received 80 messages, 0 notifications, 0 in queue
  Sent 49 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 0, Offset 0, Mask 0x1
  Community attribute sent to this neighbor (both)
  0 accepted prefixes
  0 announced prefixes

For address family: Link-State Link-State
  BGP table version 3, neighbor version 3
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  31 accepted prefixes
  9 announced prefixes

Connections established 1; dropped 0
Local host: 13.1.1.2, Local port: 179
Foreign host: 13.1.1.1, Foreign port: 45926
Nexthop: 13.1.1.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

BGP neighbor is 14.1.1.1, remote AS 200, local AS 300, external link
  BGP version 4, local router ID 40.1.1.2, remote router ID 5.5.5.5
  BGP state = Established, up for 00:16:33
  Last read 00:00:11, 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 Link-State Link-State: advertised and received
```

```

Received 50 messages, 0 notifications, 0 in queue
Sent 63 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
  0 announced prefixes

For address family: Link-State Link-State
  BGP table version 3, neighbor version 3
  Index 0, Offset 0, Mask 0x1
  Community attribute sent to this neighbor (both)
  9 accepted prefixes
  31 announced prefixes

Connections established 1; dropped 0
Local host: 14.1.1.2, Local port: 179
Foreign host: 14.1.1.1, Foreign port: 36438
Nexthop: 14.1.1.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

Controller#show bgp link-state link-state
BGP router identifier 40.1.1.2, local AS number 300
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2]] /216
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2d11.1.1.1]] /248
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]] /216
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3d12.1.1.2]] /248
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r4.4.4.4]] /216
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1]] /216
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1d10.1.1.1]] /248
e [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] /216
e [V] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r5.5.5.5]] /216
e [V] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r5.5.5.5d15.1.1.1]] /248
e [V] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r6.6.6.6]] /216
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r2.2.2.2d11.1.1.1]] [L[i11.1.1.1] [n11.1.1.1]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2d11.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r2.2.2.2]] [L[i11.1.1.1] [n11.1.1.1]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2d11.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3]] [L[i11.1.1.1] [n11.1.1.2]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r2.2.2.2d11.1.1.1]] [L[i11.1.1.2] [n11.1.1.1]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3d12.1.1.2]] [L[i12.1.1.2] [n12.1.1.2]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3]] [L[i12.1.1.2] [n12.1.1.2]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3d12.1.1.2] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r4.4.4.4]] [L[i12.1.1.2] [n12.1.1.1]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r4.4.4.4] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3d12.1.1.2]] [L[i12.1.1.1] [n12.1.1.2]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r1.1.1.1d10.1.1.1]] [L[i10.1.1.1] [n10.1.1.1]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1d10.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r1.1.1.1]] [L[i10.1.1.1] [n10.1.1.1]] /376
e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1d10.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r3.3.3.3]] [L[i10.1.1.1] [n10.1.1.2]] /376

```

```

e [E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r1.1.1.1d10.1.1.1]] [L[i10.1.1.2] [n10.1.1.1]]/376
e [E] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r5.5.5.5] [R[c200] [b5.5.5.5] [a0.0.0.0]
[r5.5.5.5d15.1.1.1]] [L[i15.1.1.1] [n15.1.1.1]]/376
e [E] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r5.5.5.5d15.1.1.1] [R[c200] [b5.5.5.5] [a0.0.0.0]
[r5.5.5.5]] [L[i15.1.1.1] [n15.1.1.1]]/376
e [E] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r5.5.5.5d15.1.1.1] [R[c200] [b5.5.5.5] [a0.0.0.0]
[r6.6.6.6]] [L[i15.1.1.1] [n15.1.1.2]]/376
e [E] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r6.6.6.6] [R[c200] [b5.5.5.5] [a0.0.0.0]
[r5.5.5.5d15.1.1.1]] [L[i15.1.1.2] [n15.1.1.1]]/376
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2]] [P[0x1] [p2.2.2.2/32]]/264
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]] [P[0x1] [p3.3.3.3/32]]/264
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]] [P[0x2] [p10.1.1.0/24]]/256
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]] [P[0x2] [p1.1.1.1/32]]/264
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r4.4.4.4]] [P[0x1] [p4.4.4.4/32]]/264
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1]] [P[0x1] [p1.1.1.1/32]]/264
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p11.1.1.0/24]]/256
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p12.1.1.0/24]]/256
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p2.2.2.2/32]]/264
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p3.3.3.3/32]]/264
e [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p4.4.4.4/32]]/264
e [T] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r5.5.5.5]] [P[0x1] [p5.5.5.5/32]]/264
e [T] [O] [I0x64] [N[c200] [b5.5.5.5] [a0.0.0.0] [r6.6.6.6]] [P[0x1] [p6.6.6.6/32]]/264
NLRIs, Total: 40, Node: 11, Link: 16, Prefix: 13

```



Note: Count of NLRIs may be different sometimes.

```

Controller#show bgp link-state link-state [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1]]/216
BGP routing table entry for [V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1]]/216
Local
  Received from 13.1.1.1
  Link State:
  Range Size: 8000  Base SID: 16000  SR Algorithm: 0
  Node flag bits: O:0 T:0 B:0 E:0
  Local TE Router-ID:1.1.1.1

```

SRMS Configuration

Configuration

R5

The following are the step-by-step configurations on the R5 router.

R5(config)#segment-routing	Entering to Segment Routing.
R5(config-sr)#mapping-server	Entering to Mapping Server
R5(config-sr-ms)#prefix-sid-map address-family ipv4	Entering to prefix-to SID mapping.
R5(config-sr-ms-map-af4)#21.21.21.21/32 4545 attached	Configure SID for prefix.
R5(config-sr-ms-map-af4)#31.31.31.31/32 3535 attached	Configure SID for prefix.
R5(config-sr-ms-map-af4)#end	Exit from SRMS.

R5#configure terminal	Entering to Config mode.
R5(config)#router ospf 100	Entering to router OSPF mode.
R5(config-router)#segment-routing prefix-sid-map advertise-local	Configure advertise-local for prefix-sid mapping.
R5(config-router)#exit	Exit from router OSPF mode

R3

The following are the step-by-step configurations on the R3 router.

R3(config)#segment-routing	Entering to Segment Routing
R3(config-sr)#mapping-server	Entering to Mapping Server
R3(config-sr-ms)#prefix-sid-map address-family ipv4	Entering to prefix-to SID mapping.
R3(config-sr-ms-map-af4)#11.11.11.11/32 1111 range 3	Configure SID for prefix.
R3(config-sr-ms-map-af4)#12.12.12.12/32 6767 range 1	Configure SID for prefix.
R3(config-sr-ms-map-af4)#end	Exit from SRMS.
R3#configure terminal	Entering to Config mode.
R3(config)#router ospf 100	Entering to router OSPF mode.
R3(config-router)#segment-routing prefix-sid-map advertise-local	Configure advertise-local for prefix-sid mapping.
R3(config-router)#exit	Exit from router OSPF mode

Validation

R3

Validation for OSPF Database

```
R3#show ip ospf database opaque-area self-originate

      OSPF Router with ID (3.3.3.3) (Process ID 100 VRF default)

        Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 851
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 3.3.3.3
LS Seq Number: 80000003
Checksum: 0x34e0
Length: 28

MPLS TE router ID : 3.3.3.3
```

Number of Links : 0

LS age: 1421
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.22 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 22
 Advertising Router: 3.3.3.3
 LS Seq Number: 80000002
 Checksum: 0xb77f
 Length: 108

Link connected to Broadcast network

Link ID : 11.1.1.1
 Interface Address : 11.1.1.2
 Admin Metric : 1
 Maximum bandwidth : 10000000.00 Kbits/s
 Maximum reservable bandwidth : 10000000.00 Kbits/s
 Unreserved Bandwidth :
 Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s	Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s	Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s	Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s	Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 1321
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 1.0.0.32 (Area-Local Opaque-Type/ID)
 Opaque Type: 1
 Opaque ID: 32
 Advertising Router: 3.3.3.3
 LS Seq Number: 80000002
 Checksum: 0x9792
 Length: 108

Link connected to Broadcast network

Link ID : 12.1.1.2
 Interface Address : 12.1.1.2
 Admin Metric : 1
 Maximum bandwidth : 10000000.00 Kbits/s
 Maximum reservable bandwidth : 10000000.00 Kbits/s
 Unreserved Bandwidth :
 Number of Priority : 8

Priority 0 : 10000000.00 Kbits/s	Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s	Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s	Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s	Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 153
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: Area-Local Opaque-LSA
 Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
 Opaque Type: 4
 Opaque ID: 0
 Advertising Router: 3.3.3.3
 LS Seq Number: 80000003
 Checksum: 0x73c4
 Length: 52

Range Size: 8000
 Base-SID: 16000

```
Algorithm0: 0
Preference: 128
```

```
LS age: 1081
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0x085d
Length: 68
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 3.3.3.3
Flags: 0x08 (-|-|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18003
```

```
Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 1.1.1.1
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18001
```

```
LS age: 153
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 1
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0x6cb2
Length: 48
```

```
Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 3
Flags: 0x00 (-|-|-|-|-|-|-)
Address Prefix: 11.11.11.11
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1111
```

```
LS age: 153
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.2 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 2
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0xe30a
```

```

Length: 48

Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 1
Flags: 0x00 (-|-|-|-|-|-|-)
Address Prefix: 12.12.12.12
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 6767

LS age: 471
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.25 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10009
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0x06c4
Length: 48

Link Type: 2
Link ID: 11.1.1.1
Link Data: 11.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24321

LS age: 171
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.30 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10014
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0xf4af
Length: 52

Link Type: 2
Link ID: 12.1.1.2
Link Data: 12.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 4.4.4.4
SID: 24322

Area-Local Opaque-LSA (Area 0.0.0.1)

LS age: 1601
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0x36df
Length: 28

MPLS TE router ID : 3.3.3.3

```



```

Number of Links : 0

LS age: 1451
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.12 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 12
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0xed55
Length: 108

Link connected to Broadcast network
Link ID : 10.1.1.1
Interface Address : 10.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s

Number of Links : 1

LS age: 153
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 3.3.3.3
LS Seq Number: 80000003
Checksum: 0x73c4
Length: 52

Range Size: 8000
Base-SID: 16000
Algorithm0: 0
Preference: 128

LS age: 861
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 3.3.3.3
LS Seq Number: 80000003
Checksum: 0x6de1
Length: 92

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0xc0 (A|N|-|-|-|-|-)
Address Prefix: 3.3.3.3
Flags: 0x08 (-|-|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18003

Prefix type : Extended Prefix TLV

```

```

Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 2.2.2.2
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18002

Prefix type : Extended Prefix TLV
Route Type: 3
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 4.4.4.4
Flags: 0x48 (-|NP|-|-|V|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 18004

LS age: 153
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 1
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0x6cb2
Length: 48

Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 3
Flags: 0x00 (-|-|-|-|-|-|-|-)
Address Prefix: 11.11.11.11
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1111

LS age: 153
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.2 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 2
Advertising Router: 3.3.3.3
LS Seq Number: 80000001
Checksum: 0xe30a
Length: 48

Prefix type : Extended Prefix Range TLV
Prefix Length: 32
AF: 0
Range: 1
Flags: 0x00 (-|-|-|-|-|-|-|-)
Address Prefix: 12.12.12.12
Flags: 0x20 (-|-|M|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 6767

LS age: 641
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA

```

```

Link State ID: 8.0.39.20 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10004
Advertising Router: 3.3.3.3
LS Seq Number: 80000002
Checksum: 0x01d1
Length: 48

```

```

Link Type: 2
Link ID: 10.1.1.1
Link Data: 10.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-)
MT-ID: 0
SID: 24320

```

NLRI count

Validation for NLRI count

```

R3#sho bgp link-state link-state count
-----
Total   NLRIs   : 44
Node    NLRIs   : 11
Link    NLRIs   : 16
Prefix  NLRIs   : 17

```



Note: Count of NLRIs may be different sometimes.

R3

Validation for R3 router.

```

R3#show bgp link-state link-state self-originate
BGP router identifier 3.3.3.3, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2]]/216
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2d11.1.1.1]]/248
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]]/216
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3d12.1.1.2]]/248
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r4.4.4.4]]/216
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1]]/216
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1d10.1.1.1]]/248
[V] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]]/216
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r2.2.2.2d11.1.1.1]] [L[i11.1.1.1] [n11.1.1.1]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2d11.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r2.2.2.2]] [L[i11.1.1.1] [n11.1.1.1]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2d11.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3]] [L[i11.1.1.1] [n11.1.1.2]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r2.2.2.2d11.1.1.1]] [L[i11.1.1.2] [n11.1.1.1]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3d12.1.1.2]] [L[i12.1.1.2] [n12.1.1.2]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3d12.1.1.2] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3]] [L[i12.1.1.2] [n12.1.1.2]]/376

```

```
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3d12.1.1.2] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r4.4.4.4]] [L[i12.1.1.2] [n12.1.1.1]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r4.4.4.4] [R[c100] [b3.3.3.3] [a0.0.0.0]
[r3.3.3.3d12.1.1.2]] [L[i12.1.1.1] [n12.1.1.2]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r1.1.1.1d10.1.1.1]] [L[i10.1.1.1] [n10.1.1.1]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1d10.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r1.1.1.1]] [L[i10.1.1.1] [n10.1.1.1]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1d10.1.1.1] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r3.3.3.3]] [L[i10.1.1.1] [n10.1.1.2]]/376
[E] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3] [R[c100] [b3.3.3.3] [a0.0.0.1]
[r1.1.1.1d10.1.1.1]] [L[i10.1.1.2] [n10.1.1.1]]/376
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r2.2.2.2]] [P[0x1] [p2.2.2.2/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]] [P[0x1] [p3.3.3.3/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]] [P[0x2] [p10.1.1.0/24]]/256
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r3.3.3.3]] [P[0x2] [p1.1.1.1/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.0] [r4.4.4.4]] [P[0x1] [p4.4.4.4/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r1.1.1.1]] [P[0x1] [p1.1.1.1/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x0] [p11.11.11.11/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x0] [p12.12.12.12/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p11.1.1.0/24]]/256
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p12.1.1.0/24]]/256
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p2.2.2.2/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p3.3.3.3/32]]/264
[T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x2] [p4.4.4.4/32]]/264
NLRI's, Total: 33, Node: 8, Link: 12, Prefix: 13
```



Note: Count of NLRIs may be different sometimes.



Note: Here the total number of NLRI increases because of prefixes configured in SRMS.

Validation for Particular NLRI

Verify the prefix-NLRIs for prefixes configured in SRMS.

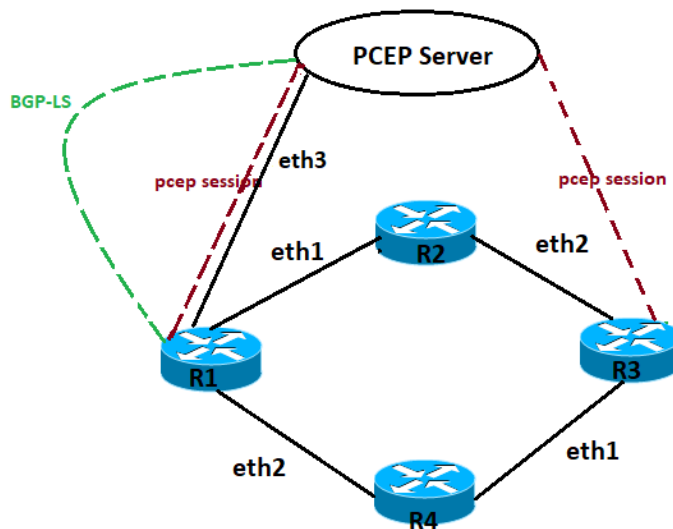
```
R3#show bgp link-state link-state [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x0]
[p11.11.11.11/32]]/264
BGP routing table entry for [T] [O] [I0x64] [N[c100] [b3.3.3.3] [a0.0.0.1] [r3.3.3.3]] [P[0x0]
[p11.11.11.11/32]]/264
Local
  Received from IGP
  Link State:
  SRMS SID: Start: 1111 Range: 3 Algorithm: 0 SRMS Flags: IA:0
  SR SID Flags: NP:0 M:1 E:0 V:0 L:0
  Source Router ID:3.3.3.3
  Local TE Router-ID:3.3.3.3
```

PCEP Segment Routing

This section describes segment routing configurations requesting path computation from the PCE server.

Topology

Figure 54. PCEP-SR topology



Configuration

R1

The following are the step-by-step configurations on the R1 router.

R1#configure terminal	Enter configure mode.
R1(config)#interface lo	Enter interface mode.
R1(config-if)#ip address 1.1.1.1/32 secondary	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)# prefix-sid absolute 16001 no php	Configure prefix SID absolute value.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface eth1	Enter interface mode.
R1(config-if)#ip address 11.1.1.1/24	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#isis network point-to-point	ISIS network type as point-to-point

R1(config-if)#label-switching	Enable label switching.
R1(config)#interface eth2	Enter interface mode.
R1(config-if)#ip address 12.1.1.1/24	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#label-switching	Enable label switching.
R1(config-if)#isis network point-to-point	ISIS network type as point-to-point
R1(config-if)#exit	Exit interface mode.
R1(config)#interface eth3	Enter interface mode.
R1(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface towards PCE
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#label-switching	Enable label switching.
R1(config-if)#isis network point-to-point	Network type as point-to-point
R1(config-if)#exit	Exit interface mode.
R1(config)#router isis 1	Set the routing process ID .
R1(config-router)#is-type level-1	Configure is-type.
R1(config-router)#distribute bgp-ls	Link State distribution to BGP
R1(config-router)#metric-style wide level-1	Configure metric style as wide.
R1(config-router)# net 49.0001.0000.0000.0011.00	Configure Network entity title (NET).
R1(config-router)#mpls traffic-eng router-id 1.1.1.1	Enable MPLS Traffic Engineering under router process.
R1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R1(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R1(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range
R1(config-router)#segment-routing mpls	Enable segment routing under router process.
R1(config-router)#exit	Exit router mode.
R1(config)#segment-routing	Configuring segment-routing
R1(config-sr)#traffic-engineering	Segment Routing traffic engineering
R1(config-sr-te)#policy policy-to-R3	Policy configuration with name 1
R1(config-sr-pol)#color 1 end-point 3.3.3.3	SR-policy color and end-point
R1(config-sr-pol-cp)#candidate-path 100	SR policy candidate path
R1(config-sr-pol-cp)#preference 100	Candidate Path preference
R1(config-sr-pol-cp)# dynamic-path pcep	Dynamic path as PCEP
R1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode

R1(config-sr-pol)#pce entity 1	Assign the PCE entity 1 to the SR policy
R1(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode
R1(config-sr-te)#exit-te	Exit from traffic engineering configuration mode
R1(config)# router bgp 100	Configure router BGP in AS 100
R1(config-router)# bgp router-id 1.1.1.1	router identifier for BGP
R1(config-router)# neighbor 33.33.33.33 remote-as 100	Configure neighbor in remote-as 100
R1(config-router)# neighbor 33.33.33.33 update-source lo	Configure neighbor with update-source loopback
R1(config-router)# address-family link-state link-state	Enter link-state Address family mode
R1(config-router-af)# neighbor 33.33.33.33 activate	Activate PCE neighbor
R1(config-router-af)# exit-address-family	Exit from Address Family configuration mode
R1(config-router)#exit	Exit router mode.
R1(config)# pce configuration 1	Configure Path Computation Client with entity 1
R1(config-pcep)#capability	Enter capabilities submode
R1(config-pcep-cap)#segment-routing pcep	Segment routing capability for PCE
R1(config-pcep-cap)# pce instantiation	PCE Initiated LSP Instantiation
R1(config-pcep-cap)# exit-capability	Exit from PCEP Entity Capability mode
R1(config-pcep)# update-source 1.1.1.1	Source of routing updates
R1(config-pcep)# peer-address ipv4 33.33.33.33	Configure peer address
R1(config-pcep)# exit	Exit PCEP mode.

R2

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Enter interface mode.
R2(config-if)#ip address 2.2.2.2/32 secondary	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)# prefix-sid absolute 16002 no php	Configure prefix SID absolute value.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface eth1	Enter interface mode.
R2(config-if)#ip address 11.1.1.2/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

R2(config-if)#isis network point-to-point	ISIS network type as point-to-point
R2(config-if)#label-switching	Enable label switching.
R2(config)#interface eth2	Enter interface mode.
R2(config-if)#ip address 6.1.1.1/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)#label-switching	Enable label switching.
R2(config-if)#isis network point-to-point	ISIS network type as point-to-point
R2(config-if)#exit	Exit interface mode.
R2(config)#router isis 1	Set the routing process ID .
R2(config-router)#is-type level-1	Configure is-type.
R2(config-router)#metric-style wide level-1	Configure metric style as wide.
R2(config-router)# net 49.0001.0000.0000.0022.00	Configure Network entity title (NET).
R2(config-router)#mpls traffic-eng router-id 2.2.2.2	Enable MPLS Traffic Engineering under router process.
R2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R2(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R2(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range
R2(config-router)#segment-routing mpls	Enable segment routing under router process.
R2(config-router)#exit	Exit router mode.

R3

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Enter interface mode.
R3(config-if)#ip address 3.3.3.3/32 secondary	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)# prefix-sid absolute 16003 no php	Configure prefix SID absolute value.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface eth1	Enter interface mode.
R3(config-if)#ip address 9.1.1.2/24	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#isis network point-to-point	ISIS network type as point-to-point

R3(config-if)#label-switching	Enable label switching.
R3(config)#interface eth2	Enter interface mode.
R3(config-if)#ip address 6.1.1.2/24	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#label-switching	Enable label switching.
R3(config-if)#isis network point-to-point	ISIS network type as point-to-point
R3(config-if)#exit	Exit interface mode.
R3(config)#router isis 1	Set the routing process ID .
R3(config-router)#is-type level-1	Configure is-type.
R3(config-router)#distribute bgp-ls	Link State distribution to BGP
R3(config-router)#metric-style wide level-1	Configure metric style as wide.
R3(config-router)# net 49.0001.0000.0000.0033.00	Configure Network entity title (NET).
R3(config-router)#mpls traffic-eng router-id 3.3.3.3	Enable MPLS Traffic Engineering under router process.
R3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R3(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R3(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range
R3(config-router)#segment-routing mpls	Enable segment routing under router process.
R3(config-router)#exit	Exit router mode.
R3(config)# pce configuration 1	Configure Path Computation Client
R3(config-pcep)#capability	Specify capabilities of entity
R3(config-pcep-cap)#segment-routing pcep	Segment routing for PCE
R3(config-pcep-cap)# pce instantiation	PCE Initiated LSP Instantiation
R3(config-pcep-cap)# exit-capability	Exit from PCEP Entity Capability mode
R3(config-pcep)# update-source 3.3.3.3	Source of routing updates
R3(config-pcep)# peer-address ipv4 33.33.33.33	Configure peer address
R3(config-pcep)# exit	Exit PCEP mode.

R4

The following are the step-by-step configurations on the R4 router.

R4#configure terminal	Enter configure mode.
R4(config)#interface lo	Enter interface mode.
R4(config-if)#ip address 4.4.4.4/32 secondary	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1

	instance.
R4(config-if)# prefix-sid absolute 16004 no php	Configure prefix sid absolute value.
R4(config-if)#exit	Exit interface mode.
R4(config)#interface eth1	Enter interface mode.
R4(config-if)#ip address 9.1.1.1/24	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R4(config-if)#isis network point-to-point	ISIS network type as point-to-point
R4(config-if)#label-switching	Enable label switching.
R4(config)#interface eth2	Enter interface mode.
R4(config-if)#ip address 12.1.1.2/24	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R4(config-if)#label-switching	Enable label switching.
R4(config-if)#isis network point-to-point	ISIS network type as point-to-point
R4(config-if)#exit	Exit interface mode.
R4(config)#router isis 1	Set the routing process ID .
R4(config-router)#is-type level-1	Configure is-type.
R4(config-router)#metric-style wide level-1	Configure metric style as wide.
R4(config-router)# net 49.0001.0000.0000.0044.00	Configure Network entity title (NET).
R4(config-router)#mpls traffic-eng router-id 4.4.4.4	Enable MPLS Traffic Engineering under router process.
R4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R4(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R4(config-router)# isis segment-routing global block 16000 19999	SRGB Starting and End Range
R4(config-router)#segment-routing mpls	Enable segment routing under router process.
R4(config-router)#exit	Exit router mode.

Validation

R1

Validation for R1 router.

```
R1#show segment-routing policy
```

Policy-Name	State	Forwarding-Info	Color	End-	
point					
policy-to-					
R3			1	3.3.3.3	UP 1600
3/eth2					

```
R1#show segment-routing policy detail
```

```
Policy-Name: policy-to-R3      Color 1      End-point 3.3.3.3      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:07:04
State Transition Count: 1
CSPF Retry Limit: 10      CSPF Retry Interval: 10
PCE Entity ID: 1
Binding SID :
BSID: 25600
Alloc mode: Dynamic
Oper State: Programmed

CP ID: 100, Active
Preference: 100      Path Type: Dynamic(pcep)      CP Origin: Local
Segment List:
Total no. of segments: 1
Segment0[LABEL]: Label :16003
Out-if: eth2      Out-label-stack: 16003
Attributes:
Configured:
Affinity:
Metric-type: TE
IP Constraints:
```

```
R1# 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
```

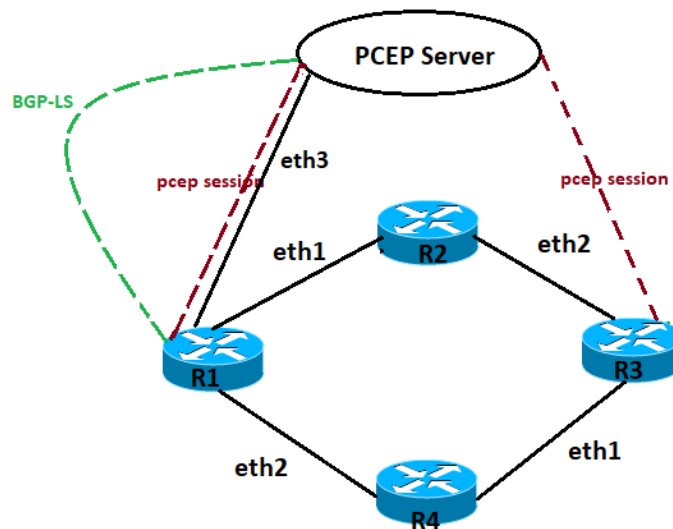
Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-
Intf	ELC	Nextthop					
i>	2.2.2.2/32	2	0	Yes	LSP_		
DEFAULT	16002	eth1	No	11.1.1.2			
P>	3.3.3.3/32	5	1	Yes	LSP_		
DEFAULT	16003	eth2	No	12.1.1.2			
i	3.3.3.3/32	4	0	Yes	LSP_		
DEFAULT	16003	eth2	No	12.1.1.2			
i>	4.4.4.4/32	3	0	Yes	LSP_		
DEFAULT	16004	eth2	No	12.1.1.2			
i>	33.33.33.33/32	1	0	Yes	LSP_		
DEFAULT	3	eth3	No	20.1.1.2			

PCEP RSVP

This section describes RSVP configurations requesting path computation from the PCE server.

Topology

Figure 55. PCEP-RSVP topology



Configuration

R1

The following are the step-by-step configurations on the R1 router.

R1#configure terminal	Enter configure mode.
R1(config)#interface lo	Enter interface mode.
R1(config-if)#ip address 1.1.1.1/32 secondary	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#exit	Exit interface mode.
R1(config)#router rsvp	Configure RSVP globally.
R1(config-router)#exit	Exit router RSVP mode.
(config)# rsvp-trunk to-R3 ipv4	Configure RSVP trunk with IPv4 address family
(config-trunk)# to 3.3.3.3	Tunnel egress IP address
(config-trunk)# path-option dynamic pce	Configure path option as PCE

(config-trunk)# pce entity 1	Assign to the PCE entity 1
R1(config)#interface eth1	Enter interface mode.
R1(config-if)#ip address 11.1.1.1/24	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#isis network point-to-point	Network-type as point-to-point
R1(config-if)#label-switching	Enable label switching.
R1(config-if)# enable-rsvp	Enable RSVP on this interface
R1(config)#interface eth2	Enter interface mode.
R1(config-if)#ip address 12.1.1.1/24	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#label-switching	Enable label switching.
R1(config-if)#isis network point-to-point	Network-type as point-to-point
R1(config-if)# enable-rsvp	Enable RSVP on this interface
R1(config-if)#exit	Exit interface mode.
R1(config)#interface eth3	Enter interface mode.
R1(config-if)#ip address 20.1.1.1/24	Configure the IP address of the interface towards PCE
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#label-switching	Enable label switching.
R1(config-if)#isis network point-to-point	Network type as point-to-point
R1(config-if)#exit	Exit interface mode.
R1(config)#router isis 1	Set the routing process ID .
R1(config-router)#is-type level-1	Configure is-type.
R1(config-router)#distribute bgp-ls	Link State distribution to BGP
R1(config-router)#metric-style wide level-1	Configure metric style as wide.
R1(config-router)# net 49.0001.0000.0000.0011.00	Configure Network entity title (NET).
R1(config-router)#mpls traffic-eng router-id 1.1.1.1	Enable MPLS Traffic Engineering under router process.
R1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R1(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R1(config-router)#exit	Exit router mode.
R1(config)# router bgp 100	Configure router BGP in AS 100
R1(config-router)# bgp router-id 1.1.1.1	Router identifier for BGP
R1(config-router)# neighbor 33.33.33.33 remote-as 100	Configure neighbor in remote-as 100

R1(config-router)# neighbor 33.33.33.33 update-source lo	Configure neighbor with update-source loopback
R1(config-router)# address-family link-state link-state	Enter link-state Address family mode
R1(config-router-af)# neighbor 33.33.33.33 activate	Activate PCE neighbor
R1(config-router-af)# exit-address-family	Exit from Address Family configuration mode
R1(config-router)#exit	Exit router mode.
R1(config)# pce configuration 1	Configure Path Computation Client with entity 1
R1(config-pcep)#capability	Enter capabilities submodule
R1(config-pcep-cap)# pce instantiation	PCE Initiated LSP Instantiation
R1(config-pcep-cap)# exit-capability	Exit from PCEP Entity Capability mode
R1(config-pcep)# update-source 1.1.1.1	Source of routing updates
R1(config-pcep)# peer-address ipv4 33.33.33.33	Configure peer address
R1(config-pcep)# exit	Exit PCEP mode.

R2

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Enter interface mode.
R2(config-if)#ip address 2.2.2.2/32 secondary	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)#exit	Exit interface mode.
R2(config)#router rsvp	Configure RSVP globally.
R2(config-router)#exit	Exit router RSVP mode.
R2(config)#interface eth1	Enter interface mode.
R2(config-if)#ip address 11.1.1.2/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)#isis network point-to-point	Network-type as point-to-point
R2(config-if)#label-switching	Enable label switching.
R2(config-if)# enable-rsvp	Enable RSVP on this interface
R2(config)#interface eth2	Enter interface mode.
R2(config-if)#ip address 6.1.1.1/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

R2(config-if)#label-switching	Enable label switching.
R2(config-if)#isis network point-to-point	Network-type as point-to-point
R2(config-if)# enable-rsvp	Enable RSVP on this interface
R2(config-if)#exit	Exit interface mode.
R2(config)#router isis 1	Set the routing process ID .
R2(config-router)#is-type level-1	Configure is-type.
R2(config-router)#metric-style wide level-1	Configure metric style as wide.
R2(config-router)# net 49.0001.0000.0000.0022.00	Configure Network entity title (NET).
R2(config-router)#mpls traffic-eng router-id 2.2.2.2	Enable MPLS Traffic Engineering under router process.
R2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R2(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R2(config-router)#exit	Exit router mode.

R3

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Enter interface mode.
R3(config-if)#ip address 3.3.3.3/32 secondary	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#exit	Exit interface mode.
R3(config)#router rsvp	Configure RSVP globally.
R3(config-router)#exit	Exit router RSVP mode.
R3(config)#interface eth1	Enter interface mode.
R3(config-if)#ip address 9.1.1.2/24	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#isis network point-to-point	Network-type as point-to-point
R3(config-if)#label-switching	Enable label switching.
R3(config-if)# enable-rsvp	Enable RSVP on this interface
R3(config)#interface eth2	Enter interface mode.
R3(config-if)#ip address 6.1.1.2/24	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.

R3(config-if)#label-switching	Enable label switching.
R3(config-if)#isis network point-to-point	Network-type as point-to-point
R3(config-if)# enable-rsvp	Enable RSVP on this interface
R3(config-if)#exit	Exit interface mode.
R3(config)#router isis 1	Set the routing process ID .
R3(config-router)#is-type level-1	Configure is-type.
R3(config-router)#distribute bgp-ls	Link State distribution to BGP
R3(config-router)#metric-style wide level-1	Configure metric style as wide.
R3(config-router)# net 49.0001.0000.0000.0033.00	Configure Network entity title (NET).
R3(config-router)#mpls traffic-eng router-id 3.3.3.3	Enable MPLS Traffic Engineering under router process.
R3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R3(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R3(config-router)#exit	Exit router mode.
R3(config)# pce configuration 1	Configure Path Computation Client
R3(config-pcep)#capability	Specify capabilities of entity
R3(config-pcep-cap)# pce instantiation	PCE Initiated LSP Instantiation
R3(config-pcep-cap)# exit-capability	Exit from PCEP Entity Capability mode
R3(config-pcep)# update-source 3.3.3.3	Source of routing updates
R3(config-pcep)# peer-address ipv4 33.33.33.33	Configure peer address
R3(config-pcep)# exit	Exit PCEP mode.

R4

The following are the step-by-step configurations on the R4 router.

R4#configure terminal	Enter configure mode.
R4(config)#interface lo	Enter interface mode.
R4(config-if)#ip address 4.4.4.4/32 secondary	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R4(config-if)#exit	Exit interface mode.
R4(config)#router rsvp	Configure RSVP globally.
R4(config-router)#exit	Exit router RSVP mode.
R4(config)#interface eth1	Enter interface mode.
R4(config-if)#ip address 9.1.1.1/24	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1

	instance.
R4(config-if)#isis network point-to-point	Network-type as point-to-point
R4(config-if)# enable-rsvp	Enable RSVP on this interface
R4(config-if)#label-switching	Enable label switching.
R4(config)#interface eth2	Enter interface mode.
R4(config-if)#ip address 12.1.1.2/24	Configure the IP address of the interface.
R4(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R4(config-if)#label-switching	Enable label switching.
R4(config-if)#isis network point-to-point	Network-type as point-to-point
R4(config-if)# enable-rsvp	Enable RSVP on this interface
R4(config-if)#exit	Exit interface mode.
R4(config)#router isis 1	Set the routing process ID .
R4(config-router)#is-type level-1	Configure is-type.
R4(config-router)#metric-style wide level-1	Configure metric style as wide.
R4(config-router)# net 49.0001.0000.0000.0044.00	Configure Network entity title (NET).
R4(config-router)#mpls traffic-eng router-id 4.4.4.4	Enable MPLS Traffic Engineering under router process.
R4(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R4(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R4(config-router)#exit	Exit router mode.

Validation

R1

Validation for R1 router.

```

R1#sho 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      to-R3-Primary  UP    00:02:44  1  1
SE        -    24960   DEFAULT
Total 1 displayed, Up 1, Down 0.

R1#sho rsvp session to-R3 primary
Ingress (Primary)
3.3.3.3
  From: 1.1.1.1, LSPstate: Up, LSPname: to-R3-Primary
  Ingress FSM state: Operational

```

```
Establishment Time: 0s 6ms
Setup priority: 7, Hold priority: 0
CSPF usage: Path Computation Element
LSP Re-Optimization: Disabled, Re-Optimization Timer: NA, Cspf Client: NA
IGP-Shortcut: Disabled, LSP metric: 20
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: 1.1.1.1
Bind value: 0, Oper state: NA, Alloc mode: NA
Downstream: 12.1.1.2, eth2
Path refresh: 30 seconds (RR enabled) (due in 29830 seconds)
Resv lifetime: 157 seconds (due in 154 seconds)
Retry count: 0, intrvl: 30 seconds
RRO re-use as ERO: Disabled
Label Recording: Disabled
Admin Groups: none
Configured Path: none
Session Explicit Route Detail :
  12.1.1.2/32 strict
  9.1.1.2/32 strict
Record route:
-----
IP Address      Label
-----
<self>
12.1.1.2
9.1.1.2
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
```

BGP Link-State Egress Peer Engineering

Overview

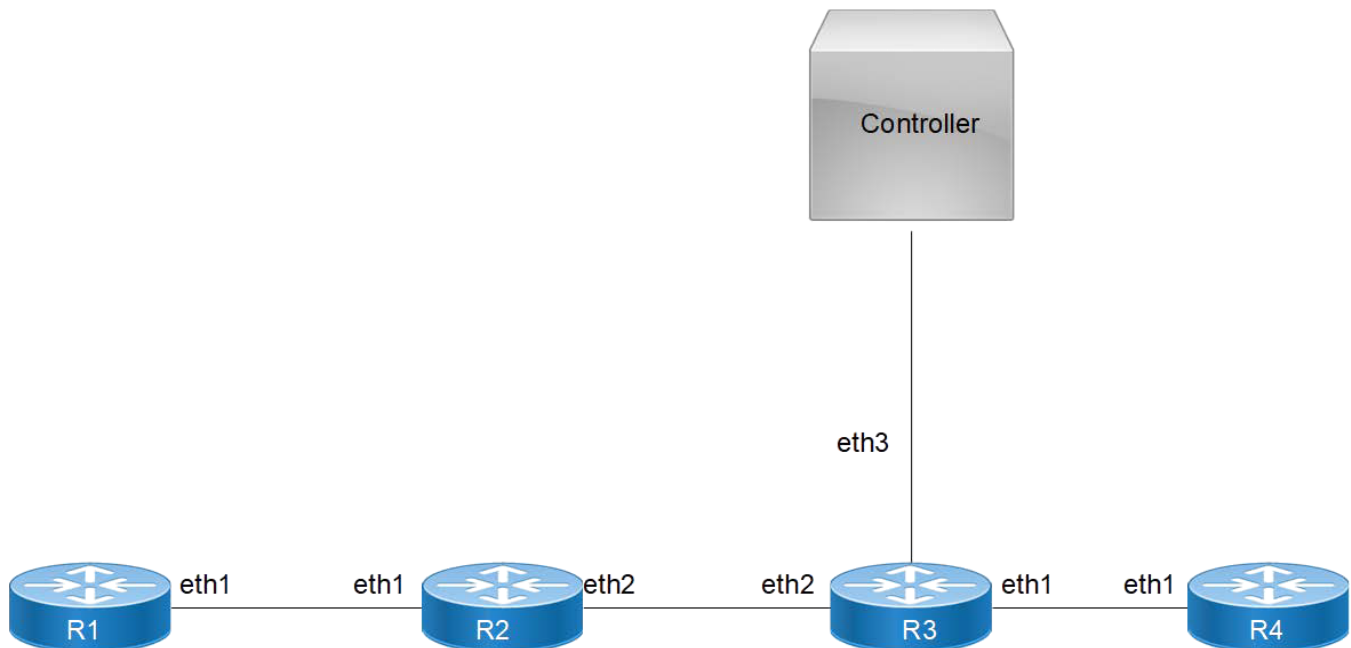
EPE or egress peer engineering will be configured mostly on the ASBRs where it labels the ASBR peer and the same information is shared with the controller using BGP LS. The controller should instruct PE to use a specific egress ASBR to reach a particular destination. The SR architecture defines three types of BGP Peering Segments that may be instantiated at a BGP node:

- Peer Node Segment (PeerNode SID) : instruction to steer to a specific peer node
- Peer Adjacency Segment (PeerAdj SID) : instruction to steer over a specific local interface towards a specific peer node
- Peer Set Segment (PeerSet SID) : instruction to load-balance to a set of specific peer nodes

Topology

Below topology displays a sample BGP LS EPE configuration.

Figure 56. BGP LS EPE Configuration



Configuration for BGP LS EPE

Configuration

R1

The following are the step-by-step configurations on the R1 router.

R1#configure terminal	Enter configure mode.
R1(config)#interface lo	Enter interface mode.
R1(config-if)#ip address 11.11.11.1/32 secondary	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)# prefix-sid index 10 no-php	Configure prefix SID index value.
R1(config-if)#exit	Exit interface mode.
R1(config)#interface eth1	Enter interface mode.
R1(config-if)#ip address 61.1.1.1/24	Configure the IP address of the interface.
R1(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R1(config-if)#isis network point-to-point	ISIS network type as point-to-point
R1(config-if)#label-switching	Enable label switching.
R1(config)#router isis 1	Set the routing process ID .
R1(config-router)#is-type level-1	Configure is-type.
R1(config-router)#metric-style wide level-1	Configure metric style as wide.
R1(config-router)# net 49.0001.0000.0000.0011.00	Configure Network entity title (NET).
R1(config-router)#mpls traffic-eng router-id 11.11.11.1	Enable MPLS Traffic Engineering under router process.
R1(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R1(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R1(config-router)#segment-routing mpls	Enable segment routing under router process.
R1(config-router)#exit	Exit router mode.
R1(config)# pce configuration 100	Configure Path Computation Client with entity 100
R1(config-pcep)#capability	Enter capabilities submode
R1(config-pcep-cap)#segment-routing pcep	Segment routing capability for PCE
R1(config-pcep-cap)# pce instantiation	PCE Initiated LSP Instantiation
R1(config-pcep-cap)# exit-capability	Exit from PCEP Entity Capability mode
R1(config-pcep)# update-source 11.11.11.1	Source of routing updates
R1(config-pcep)# peer-address ipv4 33.33.33.33	Configure peer address
R1(config-pcep)# exit	Exit PCEP mode.
R1(config)#segment-routing	Configuring segment-routing
R1(config-sr)#traffic-engineering	Segment Routing traffic engineering
R1(config-sr-te)#policy policy-to-R4	Policy configuration with name
R1(config-sr-pol)#color 1 end-point 4.1.1.2	SR-policy color and end-point
R1(config-sr-pol-cp)#candidate-path 100	SR policy candidate path

R1(config-sr-pol-cp)#preference 100	Candidate Path preference
R1(config-sr-pol-cp)# dynamic-path pcep	Dynamic path as pcep
R1(config-sr-pol-cp)#exit-pol-cp	Exit from SR policy candidate path configuration mode
R1(config-sr-pol)#pce entity 100	Assign the PCE entity 100 to the SR policy
R1(config-sr-pol)#exit-sr-pol	Exit from SR policy configuration mode
R1(config-sr-te)#exit-te	Exit from traffic engineering configuration mode

R2

The following are the step-by-step configurations on the R2 router.

R2#configure terminal	Enter configure mode.
R2(config)#interface lo	Enter interface mode.
R2(config-if)#ip address 21.21.21.21/32 secondary	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)# prefix-sid index 20 no-php	Configure prefix SID index value.
R2(config-if)#exit	Exit interface mode.
R2(config)#interface eth1	Enter interface mode.
R2(config-if)#ip address 61.1.1.2/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)#isis network point-to-point	ISIS network type as point-to-point
R2(config-if)#label-switching	Enable label switching.
R2(config)#interface eth2	Enter interface mode.
R2(config-if)#ip address 12.1.1.1/24	Configure the IP address of the interface.
R2(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R2(config-if)#label-switching	Enable label switching.
R2(config-if)#isis network point-to-point	ISIS network type as point-to-point
R2(config-if)#exit	Exit interface mode.
R2(config)#router isis 1	Set the routing process ID .
R2(config-router)#is-type level-1	Configure is-type.
R2(config-router)#metric-style wide level-1	Configure metric style as wide.
R2(config-router)# net 49.0001.0000.0000.0022.00	Configure Network entity title (NET).
R2(config-router)#mpls traffic-eng router-id 21.21.21.21	Enable MPLS Traffic Engineering under router

	process.
R2(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R2(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R2(config-router)#segment-routing mpls	Enable segment routing under router process.
R2(config-router)#exit	Exit router mode.

R3

The following are the step-by-step configurations on the R3 router.

R3#configure terminal	Enter configure mode.
R3(config)#interface lo	Enter interface mode.
R3(config-if)#ip address 31.31.31.31/32 secondary	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)# prefix-sid index 30 no-php	Configure prefix SID index value.
R3(config-if)#exit	Exit interface mode.
R3(config)#interface eth1	Enter interface mode.
R3(config-if)#ip address 4.1.1.1/24	Configure the IP address of the interface.
R3(config-if)#label-switching	Enable label switching.
R3(config)#interface eth2	Enter interface mode.
R3(config-if)#ip address 12.1.1.2/24	Configure the IP address of the interface.
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#label-switching	Enable label switching.
R3(config-if)#isis network point-to-point	ISIS network type as point-to-point
R3(config-if)#exit	Exit interface mode.
R3(config)#interface eth3	Enter interface mode.
R3(config-if)#ip address 9.1.1.1/24	Configure the IP address of the interface towards PCE
R3(config-if)#ip router isis 1	Make the interface part of the router ISIS 1 instance.
R3(config-if)#label-switching	Enable label switching.
R3(config-if)#isis network point-to-point	Network type as point-to-point
R3(config-if)#exit	Exit interface mode.
R3(config)#router isis 1	Set the routing process ID .

R3(config-router)#is-type level-1	Configure is-type.
R3(config-router)#distribute bgp-ls	Link State distribution to BGP
R3(config-router)#metric-style wide level-1	Configure metric style as wide.
R3(config-router)# net 49.0001.0000.0000.0033.00	Configure Network entity title (NET).
R3(config-router)#mpls traffic-eng router-id 31.31.31.31	Enable MPLS Traffic Engineering under router process.
R3(config-router)#mpls traffic-eng level-1	Enable MPLS Traffic Engineering as level-1.
R3(config-router)# capability cspf	Enable CSPF capability under ISIS 1 process.
R3(config-router)#segment-routing mpls	Enable segment routing under router process.
R3(config-router)#exit	Exit router mode.
R3(config)# router bgp 1000	Configure router BGP in AS 1000
R3(config-router)# bgp router-id 31.31.31.31	Router identifier for BGP
R3(config-router)# neighbor 9.1.1.2 remote-as 100	Configure neighbor in remote-as 100
R3(config-router)# neighbor 4.1.1.2 remote-as 2000	Configure neighbor in remote-as 2000
R3(config-router)# address-family link-state link-state	Enter link-state Address family mode
R3(config-router-af)# neighbor 9.1.1.2 activate	Activate PCE neighbor
R3(config-router-af)# exit-address-family	Exit from Address Family configuration mode
R3(config-router)# address-family ipv4 unicast	Enter link-state Address family mode
R3(config-router-af)# neighbor 4.1.1.2 activate	Activate EPE neighbor
R3(config-router-af)# exit-address-family	Exit from Address Family configuration mode
R3(config-router)# egress-engineering	Enter Egress Engineering mode
R3(config-router-af)# neighbor 4.1.1.2 peer-node	Enable peer-node SID for EPE neighbor
R3(config-router-af)# exit-address-family	Exit from Address Family configuration mode
R3(config-router)#exit	Exit router mode.

R4

The following are the step-by-step configurations on the R4 router.

R4#configure terminal	Enter configure mode.
R4(config)#interface lo	Enter interface mode.
R4(config-if)#ip address 41.41.41.41/32 secondary	Configure the IP address of the interface.
R4(config-if)#exit	Exit interface mode.
R4(config)#interface eth1	Enter interface mode.
R4(config-if)#label-switching	Enable label switching.

R4(config-if)#exit	Exit interface mode.
R4(config)# router bgp 2000	Configure router BGP in AS 2000
R4(config-router)# neighbor 4.1.1.1 remote-as 1000	Configure neighbor in remote-as 1000
R4(config-router)# address-family ipv4 unicast	Enter link-state Address family mode
R4(config-router-af)# neighbor 4.1.1.1 activate	Activate ipv4 EBGp neighbor
R4(config-router-af)# exit-address-family	Exit from Address Family configuration mode
R4(config-router)#exit	Exit router mode.

Validation

R3

Validation of R3 router

```

R3#show clns neighbors

Total number of L1 adjacencies: 2
Total number of L2 adjacencies: 0
Total number of adjacencies: 2
Tag 1: VRF : default
System Id      Interface  SNPA              State Holdtime  Type Protocol
0000.0000.3333 xe9       0032.1748.f810    Up    27         L1    IS-IS
0000.0000.0022 xe20       e8c5.7a7a.136c    Up    23         L1    IS-IS
R3#show bgp neighbors
BGP neighbor is 4.1.1.2, remote AS 2000, local AS 1000, external link
  BGP version 4, local router ID 31.31.31.31, remote router ID 4.4.4.4
  BGP state = Established, up for 00:17:08
  Last read 00:00:11, 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 44 messages, 0 notifications, 0 in queue
  Sent 43 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 3, neighbor version 3
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (both)
  2 accepted prefixes
  5 announced prefixes

  Connections established 1; dropped 0
Local host: 4.1.1.1, Local port: 59946
Foreign host: 4.1.1.2, Foreign port: 179
Nexthop: 4.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

BGP neighbor is 9.1.1.2, remote AS 100, local AS 1000, external link
  BGP version 4, local router ID 31.31.31.31, remote router ID 2.2.2.2
  BGP state = Established, up for 00:17:07
  Last read 00:00:03, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    4-Octet ASN Capability: received

```



```

    Address family IPv4 Unicast: advertised and received
    Address family Link-State Link-State: advertised and received
    Received 41 messages, 0 notifications, 0 in queue
    Sent 138 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 3, neighbor version 3
    Index 2, Offset 0, Mask 0x4
    Extended Nexthop Encoding: received
    Community attribute sent to this neighbor (both)
    5 accepted prefixes
    2 announced prefixes

For address family: Link-State Link-State
    BGP table version 17, neighbor version 17
    Index 1, Offset 0, Mask 0x2
    Community attribute sent to this neighbor (both)
    0 accepted prefixes
    31 announced prefixes

Connections established 1; dropped 0
Local host: 9.1.1.1, Local port: 58018
Foreign host: 9.1.1.2, Foreign port: 179
Nexthop: 9.1.1.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network

R3#show bgp link-state link-state summary
BGP router identifier 31.31.31.31, local AS number 1000
BGP table version is 17
2 BGP AS-PATH entries
0 BGP community entries

Neighbor          V    AS  MsgRcv   MsgSen  TblVer   InQ   OutQ   Up/Down   State/PfxRcd
9.1.1.2            4    100    41      138     17       0      0   00:17:11      0

Total number of neighbors 1

Total number of Established sessions 1
R3#

R3#show bgp epe
EPE Details for EBGp peers:

===== Peer : 4.1.1.2 =====
epe->sid_type = Peer-node-SID
in-label = 24320
nexthop = 4.1.1.2
out_intf = xe4

R3#show bgp link-state link-state
BGP router identifier 31.31.31.31, local AS number 1000
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
[V] [L1] [I0x1] [N[c1000] [b31.31.31.31] [s0000.0000.0001.00]]/208
[V] [L1] [I0x1] [N[c1000] [b31.31.31.31] [s0000.0000.0011.00]]/208
[V] [L1] [I0x1] [N[c1000] [b31.31.31.31] [s0000.0000.0022.00]]/208
[V] [L1] [I0x1] [N[c1000] [b31.31.31.31] [s0000.0000.0033.00]]/208
[V] [L1] [I0x1] [N[c1000] [b31.31.31.31] [s0000.0000.3333.00]]/208
[E] [L1] [I0x1] [N[c1000] [b31.31.31.31] [s0000.0000.0001.00]] [R[c1000] [b31.31.31.31]
[s0000.0000.2345.00]] [L[i12.1.1.2] [n12.1.1.1]]/328

```

```

[E][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0001.00]][R[c1000][b31.31.31.31]
[s0000.0000.3333.00]][L[i9.1.1.1][n9.1.1.2]]/328
[E][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0011.00]][R[c1000][b31.31.31.31]
[s0000.0000.0022.00]][L[i61.1.1.1][n61.1.1.2]]/328
[E][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0022.00]][R[c1000][b31.31.31.31]
[s0000.0000.0011.00]][L[i61.1.1.2][n61.1.1.1]]/328
[E][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0022.00]][R[c1000][b31.31.31.31]
[s0000.0000.0033.00]][L[i12.1.1.1][n12.1.1.2]]/328
[E][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0033.00]][R[c1000][b31.31.31.31]
[s0000.0000.0022.00]][L[i12.1.1.2][n12.1.1.1]]/328
[E][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0033.00]][R[c1000][b31.31.31.31]
[s0000.0000.3333.00]][L[i9.1.1.1][n9.1.1.2]]/328
[E][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.3333.00]][R[c1000][b31.31.31.31]
[s0000.0000.0033.00]][L[i9.1.1.2][n9.1.1.1]]/328
[E][B][I0x3e8][N[c1000][b31.31.31.31][b31.31.31.31][c1000]][R[c1000][b31.31.31.31][b4.4.4.4]
[c2000]][L[i4.1.1.1][n4.1.1.2]]/344
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0001.00]][P[p4.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0001.00]][P[p9.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0001.00]][P[p12.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0001.00]][P[p7.7.7.7/32]]/248
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0001.00]][P[p31.31.31.31/32]]/248
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0001.00]][P[p33.33.33.33/32]]/248
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0011.00]][P[p61.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0011.00]][P[p11.11.11.1/32]]/248
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0022.00]][P[p12.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0022.00]][P[p61.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0022.00]][P[p21.21.21.21/32]]/248
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0033.00]][P[p4.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0033.00]][P[p9.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0033.00]][P[p12.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.0033.00]][P[p31.31.31.31/32]]/248
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.3333.00]][P[p9.1.1.0/24]]/240
[T][L1][I0x1][N[c1000][b31.31.31.31][s0000.0000.3333.00]][P[p33.33.33.33/32]]/248
NLRIs, Total: 31, Node: 5, Link: 9, Prefix: 17

```

R3#

R3#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>	4.1.1.2/32	16	24320	3	N/A	xe4 4.1.1
.2		LSP_DEFAULT				
i>	31.31.31.31/32	1	16030	NoLabel	N/A	N/A 127.0
.0.1		LSP_DEFAULT				
i>	21.21.21.21/32	8	16020	16020	N/A	xe20 12.1.
1.1		LSP_DEFAULT				
i>	11.11.11.1/32	7	16010	16010	N/A	xe20 12.1.
1.1		LSP_DEFAULT				
i>	33.33.33.33/32	9	16107	3	N/A	xe9 9.1.1
.2		LSP_DEFAULT				
i>	9.1.1.2/32	2	24960	3	N/A	xe9 9.1.1
.2		LSP_DEFAULT				
i>	12.1.1.1/32	3	24961	3	N/A	xe20 12.1.
1.1		LSP_DEFAULT				

R3#

R3#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							

```

i> 11.11.11.1/32      1      6      0      Yes  LSP_
DEFAULT 16010      xe20      No  12.1.1.1
i> 21.21.21.21/32    2      9      0      Yes  LSP_
DEFAULT 16020      xe20      No  12.1.1.1
i> 33.33.33.33/32    3     25     0      Yes  LSP_
DEFAULT 3          xe9       No  9.1.1.2
R3#
R3#

```

R1

Validation of R1 router

```

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
0000.0000.0022 xe6          e8c5.7a7a.1366    Up     26        L1    IS-IS

R1#show pcep peer

=====
Path Computation Client Connection Details :
=====

PCEP entity id : 100
=====
Peer Info
-----
PCE Server IP      : 33.33.33.33
PCEP Source IP     : 11.11.11.1
PCEP Local session-id : 3
PCEP Remote session-id : 0
Session Connect Retry : 0
Session Connect due in : 0 sec
OpenRetry          : 0
Open wait due in   : 0 sec
Keep wait due in   : 0 sec
Keep alive timer due in : 3 sec
Peer Keep-alive value : 30 sec
Peer Dead timer value : 120 sec
Peer Dead timer due in : 111 sec
Peer Overloaded     : No
Peer Overload due in : 0 sec
LocalOK             : 1
RemoteOK            : 1
Max unknown messages : 0
FSM State           : Up
Total FSM State changes : 4
Peer Up time        : 00:02:26
Flap Limit Timer value : 300 Sec
Local Capabilities :
  Stateful PCE Capability : Yes
  LSP Instantiation       : Yes
  SR PCE Capability       : Yes
Remote Capabilities :
  Stateful PCE Capability : Yes
  LSP Update Capability   : Yes
  LSP Instantiation       : Yes
  SR PCE Capability       : Yes

R1#

```

```

Policy should be UP with the EPE label

R1#show segment-routing policy detail

Policy-Name: policy-to-R4      Color 1      End-point 4.1.1.2      Tunnel-ID: 1
Admin-Status: UP      Oper-Status: UP for 00:01:41
State Transition Count: 1
CSPF Retry Limit: 100      CSPF Retry Interval: 10
PCE Entity ID: 100
Binding SID :
  BSID: 24960
  Alloc mode: Dynamic
  Oper State: Programmed

CP ID: 1, Active
Preference: 100      Path Type: Dynamic(pcep)      CP Origin: Local
CP state: Valid
Segment List:
Total no. of segments: 2
Segment0[LABEL]: Label :16030
Segment1[LABEL]: Label :24320
Out-if: xe6      Out-label-stack: 16030/24320
Computed TE Metric: 20
Attributes:
  Configured:
    Affinity:
    Metric-type: TE
    IP Constraints:

R1#

```

Similarly, Peer-Adjacency SID and Peer-SET SIDs can be configured using the following CLI:

```

Neighbor <A.B.C.D> peer-adj hop-address <A.B.C.D>
Neighbor <A.B.C.D> peer-set <NAME>

```

Peer-node and peer-adj SIDs can have backups which are configured via the following CLI:

Suppose we have 2 EBGPs peers who have EPE configured:

```

Neighbor <A.B.C.D> peer-node
Neighbor <P.Q.R.S> peer-node
Neighbor <A.B.C.D> peer-adj hop-address <A.B.C.D>
Neighbor <P.Q.R.S> peer-adj hop-address <P.Q.R.S>

```

The backup for a peer-node SID can be a peer-node or peer-adj of the other peer and similarly, the backup of peer-adj SID can be a peer-node or peer-adj SID.

```

Neighbor <A.B.C.D> peer-node backup backup-type peer-node backup-peer <P.Q.R.S>
Neighbor <A.B.C.D> peer-node backup backup-type peer-adj backup-peer <P.Q.R.S> hop-address <P.Q.R.S>

```

```

Neighbor <A.B.C.D> peer-adj hop-address <A.B.C.D> backup backup-type peer-node backup-peer <P.Q.R.S>
Neighbor <A.B.C.D> peer-adj hop-address <A.B.C.D> backup backup-type peer-adj backup-peer <P.Q.R.S>
hop-address <P.Q.R.S>

```

BGP Link-State Advertisement of IGP TE

IGP Traffic Engineering Metric Extensions defined in the IS-IS and OSPF protocols can be collected from networks and shared with external components using BGP. This is achieved using a new BGP Network Layer Reachability Information (NLRI) encoding format.

This chapter contains configurations for BGP Link state advertisements for IGP TE with OSPF as IGP.

Topology

Below topology displays a sample BGP LS Advertisement of IGP TE configuration topology.

Figure 7-9: BGP LS IGP-TE configuration topology



Configuration

RTR1

The following are the step-by-step configurations on the RTR1 router.

RTR1#configure terminal	Enter configure mode.
RTR1(config)#hardware-profile filter twamp-ipv4 enable	Enabling hardware filter for ipv4 to configure measurement configs
RTR1(config)#delay-profile interfaces	Enter in to delay profile mode
RTR1(config-dp-intf)#burst-interval 1000	Configure burst interval value under delay profile mode
RTR1(config-dp-intf)#exit	Exit delay profile mode
RTR1(config)#interface lo	Enter interface mode.
RTR1(config-if)# ip address 1.1.1.1/32 secondary	Configure IP address on the loopback interface as secondary
RTR1(config-if)# prefix-sid index 1	Configure prefix-sid value
RTR1(config-if)#exit	Exit interface mode.
RTR1(config)#interface eth1	Enter interface mode.
RTR1(config-if)# ip address 23.1.1.1/24	Configure the IPv6 address of the interface.
RTR1(config-if)# label-switching	Enable label-switching on interface
RTR1(config-if)# delay-measurement dynamic twamp reflector-ip 23.1.1.2	Configuring delay measurement with reflector IP
RTR1(config)#router ospf 1	Set the routing process ID as 1

RTR1(config-router)#ospf router-id 1.1.1.1	Configure OSPF router ID
RTR1(config-router)#network 1.1.1.1/32 area 0.0.0.0	Configure OSPF network in area 0
RTR1(config-router)#network 23.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
RTR1(config-router)#segment-routing mpls	Enable segment routing MPLS under OSPF
RTR1(config-router)#exit	Exit router mode.
RTR1(config)#twamp-light control	Enter to Twamp-Light control mode
RTR1(config-twamp-light-ctrl)#control-admin-state enable	Enabling the Twamp-light Control

RTR2

The following are the step-by-step configurations on the RTR2 router.

RTR2#configure terminal	Enter configure mode.
RTR2(config)#hardware-profile filter twamp-ipv4 enable	Enabling hardware filter for ipv4 to configure measurement configs
RTR2(config)#delay-profile interfaces	Enter in to delay profile mode
RTR2(config-dp-intf)#burst-interval 1000	Configure burst interval value under delay profile mode
RTR2(config-dp-intf)#exit	Exit delay profile mode
RTR2(config)#interface lo	Enter interface mode.
RTR2(config-if)# ip address 2.2.2.2/32 secondary	Configure IP address on the loopback interface as secondary
RTR2(config-if)# prefix-sid index 2	Configure prefix-sid value
RTR2(config-if)#exit	Exit interface mode.
RTR2(config)#interface eth1	Enter interface mode.
RTR2(config-if)# ip address 23.1.1.2/24	Configure the IPv6 address of the interface.
RTR2(config-if)# label-switching	Enable label-switching on interface
RTR2(config)#interface eth2	Enter interface mode.
RTR2(config-if)# ip address 50.1.1.1/24	Configure the IPv6 address of the interface.
RTR2(config-if)# label-switching	Enable label-switching on interface
RTR2(config-if)# exit	Exit interface mode
RTR1(config)#router ospf 1	Set the routing process ID as 1
RTR2(config-router)#network 2.2.2.2/32 area 0.0.0.0	Configure OSPF network in area 0
RTR2(config-router)#network 23.1.1.0/24 area 0.0.0.0	Configure OSPF network in area 0
RTR2(config-router)#distribute bgp-ls	Link State distribution to BGP

RTR2(config-router)#segment-routing mpls	Enable segment routing MPLS under OSPF
RTR2(config-router)#exit	Exit router mode
RTR2(config)# twamp-light reflector	Enter to Twamp-Light reflector mode
RTR2(config-twamp-light-ref)#reflector-admin-state enable	Enabling the Twamp-light reflector
RTR2(config-twamp-light-ref)#reflector-name 123 reflector-ip ipv4 23.1.1.2	Configure reflector IP
RTR2(config-twamp-light-ref)# exit	Exit reflector mode
RTR2(config)# router bgp 100	Configure BGP in AS 100
RTR2(config-router)# neighbor 50.1.1.2 remote-as 100	Configure neighbor in AS 100
RTR2(config-router)# address-family link-state link-state	Configure link-state address-family
RTR2(config-router-af)# neighbor 50.1.1.2 activate	Activate neighbor under link-state add family
RTR2(config-router-af)# exit-address-family	Exit address family

RTR3

The following are the step-by-step configurations on the RTR2 router.

RTR3#configure terminal	Enter configure mode.
RTR3(config)#interface lo	Enter interface mode.
RTR3(config-if)# ip address 3.3.3.3/32 secondary	Configure IP address on the loopback interface as secondary
RTR3(config-if)# prefix-sid index 3	Configure prefix-sid value
RTR3(config-if)#exit	Exit interface mode.
RTR3(config)#interface eth2	Enter interface mode.
RTR3(config-if)# ip address 50.1.1.2/24	Configure the IPv6 address of the interface.
RTR3(config-if)# label-switching	Enable label-switching on interface
RTR3(config-if)# exit	Exit interface mode
RTR3(config)# router bgp 100	Configure BGP in AS 100
RTR3(config-router)# neighbor 50.1.1.1 remote-as 100	Configure neighbor in AS 100
RTR3(config-router)# address-family link-state link-state	Configure link-state address-family
RTR3(config-router-af)# neighbor 50.1.1.1 activate	Activate neighbor under link-state add family
RTR3(config-router-af)# exit-address-family	Exit address family

Validation

RTR1

Validation for RTR1 router.

```
RTR1#show twamp-statistics interfaces
Interface Last Advertisement Delay(us) Min(us) Max(us) Var(us) Loss(%)
eth1 2022-01-24 16:33:44 2 1 2 0 Not Enabled

RTR1#show twamp-statistics interfaces eth1
Interface name : eth1
Sender IP : 23.1.1.1
Reflector IP : 23.1.1.2
Reflector port : 862
DSCP value : 0
Last Advertised stats:
Time: 2022-01-24 16:33:44
Average delay : 2
Minimum delay : 1
Maximum delay : 2
Average delay variation: 0
Minimum delay variation: 0
Maximum delay variation: 0
Packets sent : 300
Packets received : 300
Packets timeout : 0
Packet Loss: Not Enabled
Last Calculated stats:
Time: 2022-01-24 16:38:45
Average delay : 2
Minimum delay : 1
Maximum delay : 2
Average delay variation: 0
Minimum delay variation: 0
Maximum delay variation: 0
Packets sent : 300
Packets received : 300
Packets timeout : 0
Packet Loss : Not Enabled

RTR1#show ip ospf database opaque-area

OSPF Router with ID (1.1.1.1) (Process ID 1 VRF default)

Area-Local Opaque-LSA (Area 0.0.0.0)

LS age: 1649
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 1.1.1.1
LS Seq Number: 80000009
Checksum: 0x20fe
Length: 28

MPLS TE router ID : 1.1.1.1

Number of Links : 0

LS age: 1209
Options: 0x22 (-|-|DC|-|-|-|E|-)
```



```
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.1 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 1
Advertising Router: 2.2.2.2
LS Seq Number: 80000004
Checksum: 0x2eed
Length: 28
```

MPLS TE router ID : 2.2.2.2

Number of Links : 0

```
LS age: 363
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.16 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 16
Advertising Router: 1.1.1.1
LS Seq Number: 800000d2
Checksum: 0x8931
Length: 136
```

Link connected to Broadcast network

```
Link ID : 23.1.1.2
Interface Address : 23.1.1.1
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
Link Delay : 2 us, Anomalous : 0
Link Min/Max Delay : 1/2 us, Anomalous : 0
Link Delay Variation: 0 us
```

Number of Links : 1

```
LS age: 1189
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 1.0.0.16 (Area-Local Opaque-Type/ID)
Opaque Type: 1
Opaque ID: 16
Advertising Router: 2.2.2.2
LS Seq Number: 80000004
Checksum: 0x4ed7
Length: 108
```

Link connected to Broadcast network

```
Link ID : 23.1.1.2
Interface Address : 23.1.1.2
Admin Metric : 1
Maximum bandwidth : 10000000.00 Kbits/s
Maximum reservable bandwidth : 10000000.00 Kbits/s
Unreserved Bandwidth :
Number of Priority : 8
Priority 0 : 10000000.00 Kbits/s      Priority 1 : 10000000.00 Kbits/s
Priority 2 : 10000000.00 Kbits/s      Priority 3 : 10000000.00 Kbits/s
Priority 4 : 10000000.00 Kbits/s      Priority 5 : 10000000.00 Kbits/s
Priority 6 : 10000000.00 Kbits/s      Priority 7 : 10000000.00 Kbits/s
```

Number of Links : 1

```
LS age: 839
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 1.1.1.1
LS Seq Number: 80000005
Checksum: 0xedeb
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm0: 0
```

```
LS age: 1159
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 4.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 4
Opaque ID: 0
Advertising Router: 2.2.2.2
LS Seq Number: 80000005
Checksum: 0xcf06
Length: 44
```

```
Range Size: 8000
Base-SID: 16000
Algorithm0: 0
```

```
LS age: 1319
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 1.1.1.1
LS Seq Number: 80000005
Checksum: 0xc9c7
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 1.1.1.1
Flags: 0x00 (-|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 1
```

```
LS age: 1109
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 7.0.0.0 (Area-Local Opaque-Type/ID)
Opaque Type: 7
Opaque ID: 0
Advertising Router: 2.2.2.2
LS Seq Number: 80000006
Checksum: 0xf591
Length: 44
```

```
Prefix type : Extended Prefix TLV
Route Type: 1
Prefix Length: 32
```

```

AF: 0
Flags: 0x40 (-|N|-|-|-|-|-)
Address Prefix: 2.2.2.2
Flags: 0x00 (-|-|-|-|-|-|-)
MT-ID: 0
Algorithm: 0
SID: 2

LS age: 1579
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 1.1.1.1
LS Seq Number: 80000006
Checksum: 0x704a
Length: 48

Link Type: 2
Link ID: 23.1.1.2
Link Data: 23.1.1.1
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
SID: 24320

LS age: 1699
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: Area-Local Opaque-LSA
Link State ID: 8.0.39.22 (Area-Local Opaque-Type/ID)
Opaque Type: 8
Opaque ID: 10006
Advertising Router: 2.2.2.2
LS Seq Number: 80000005
Checksum: 0xb36f
Length: 52

Link Type: 2
Link ID: 23.1.1.2
Link Data: 23.1.1.2
Flags: 0x60 (-|V|L|-|-|-|-|-)
MT-ID: 0
NBR ID: 1.1.1.1
SID: 24960

```

RTR3

Validation for RTR3 router.

```

RTR3#show bgp link-state link-state
BGP router identifier 50.1.1.2, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix, d designated router address, s ISO-ID
i [V] [O] [I0x1] [N[c100] [b23.1.1.2] [a0.0.0.0] [r1.1.1.1]]/216
i [V] [O] [I0x1] [N[c100] [b23.1.1.2] [a0.0.0.0] [r2.2.2.2]]/216
i [V] [O] [I0x1] [N[c100] [b23.1.1.2] [a0.0.0.0] [r2.2.2.2d23.1.1.2]]/248
i [E] [O] [I0x1] [N[c100] [b23.1.1.2] [a0.0.0.0] [r1.1.1.1] [R[c100] [b23.1.1.2] [a0.0.0.0]
[r2.2.2.2d23.1.1.2]] [L[i23.1.1.1] [n23.1.1.2]]/376
i [E] [O] [I0x1] [N[c100] [b23.1.1.2] [a0.0.0.0] [r2.2.2.2] [R[c100] [b23.1.1.2] [a0.0.0.0]
[r2.2.2.2d23.1.1.2]] [L[i23.1.1.2] [n23.1.1.2]]/376
i [E] [O] [I0x1] [N[c100] [b23.1.1.2] [a0.0.0.0] [r2.2.2.2d23.1.1.2] [R[c100] [b23.1.1.2] [a0.0.0.0]

```

```

[r1.1.1.1]][L[i23.1.1.2][n23.1.1.1]]/376
i [E][O][I0x1][N[c100][b23.1.1.2][a0.0.0.0][r2.2.2.2d23.1.1.2][R[c100][b23.1.1.2][a0.0.0.0]
[r2.2.2.2]][L[i23.1.1.2][n23.1.1.2]]/376
i [T][O][I0x1][N[c100][b23.1.1.2][a0.0.0.0][r1.1.1.1]][P[0x1][p1.1.1.1/32]]/264
i [T][O][I0x1][N[c100][b23.1.1.2][a0.0.0.0][r2.2.2.2]][P[0x1][p2.2.2.2/32]]/264
NLRIs, Total: 9, Node: 3, Link: 4, Prefix: 2

RTR3#show bgp link-state link-state [E][O][I0x1][N[c100][b23.1.1.2][a0.0.0.0][r1.1.1.1][R[c100]
[b23.1.1.2][a0.0.0.0][r2.2.2.2d23.1.1.2]][L[i23.1.1.1][n23.1.1.2]]/376
BGP routing table entry for [E][O][I0x1][N[c100][b23.1.1.2][a0.0.0.0][r1.1.1.1][R[c100]
[b23.1.1.2][a0.0.0.0][r2.2.2.2d23.1.1.2]][L[i23.1.1.1][n23.1.1.2]]/376
Local
  Received from 23.1.1.2
  Link State:
  Local Router ID: 1.1.1.1, Remote Router ID: 2.2.2.2
  Max link bw(kbits/sec): 10000000.00 ,Max reservable link bw(kbits/sec): 10000000.00
  Max unreserved link bw(kbits/sec):10000000.00 10000000.00 10000000.00 10000000.00 10000000.00
10000000.00 10000000.00 10000000.00
  TE metric 1 , IGP metric 1
  SR Flags: B:0 V:1 L:1 G:0 P:0
Adjacency SID: 24320 Link Delay : 2 us Anomalous : 0
  Link Min/Max Delay : 1/2 us, Anomalous : 0
  Link Delay-variation : 0 us

Local TE Router-ID:1.1.1.1

```

PATH COMPUTATION ELEMENT COMMUNICATION PROTOCOL COMMAND REFERENCE

PCEP Commands

This section describes the commands for Path Computation Element Protocol (PCEP).

capability

Use this command to enter PCEP capability mode.

Command Syntax

```
capability
```

Parameters

None

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce configuration 1
(config-pcep)#capability
(config-pcep-cap)#
```

clear pcep peer

Use this command to reset the PCEP session.

Command Syntax

```
clear pcep peer (A.B.C.D | X:X::X:X | *)
```

Parameters

A.B.C.D

PCEP IPv4 peer address

X:X::X:X

PCEP IPv6 peer address

*

All PCEP peers

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#clear pcep peer
```

clear pcep request

Use this command to re-trigger a PCEP request. If this command is ignored if an existing PCE request is in progress.

Command Syntax

```
clear pcep request (<5001-65535>|all)
```

Parameters

<5001-65535>

Tunnel-id

all

All tunnel interfaces

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#clear pcep request all

#show pcep request

=====
Path Computation Client Request Details:
=====

      Tunnel-id                : 1
      Request-id      : 1
      Ingress                        : 1.1.1.1
      Egress                        : 3.3.3.3
      Bandwidth                : 40m
      Time due                  : 0 secs
      State                    : Init
```

clear pcep statistics

Use this command to reset all PCEP statistics to zero.

Syntax

```
clear pcep statistics
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#clear pcep statistics

#show pcep statistics

=====
Path Computation Client Statistics Details:
=====

Entity Index          : 1
PCE Server IP         : 50.50.50.1
Open sent             : 0
Open rcv              : 0
Path request sent     : 0
Path response rcv     : 0
Error Sent            : 0
Error received        : 0
Notification Sent     : 0
Notification received : 0
Keepalive Sent        : 0
Keepalive received    : 0
Unknown rcv           : 0
Corrupt rcv           : 0
Request cancelled     : 0
Request rejected      : 0
Request Timed out     : 0
Request comp failed   : 0
Request with reply    : 0
```

cool-off-timeout

Use this command to set the flap dampening interval.

Use the `no` form of this command to set the flap dampening interval to its default value (300 seconds).

Syntax

```
cool-off-timeout <1-300>
```

Parameters

<1-300>

Flap dampening interval in seconds. The default value is 300 seconds.

Default

300 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce configuration 1
(config-pcep)#cool-off-timeout 150
```

deadtimer

Use this command to set the dead timer.

Use the `no` form of this command to set the dead timer to its default (120 seconds).

Command Syntax

```
deadtimer <1-255>  
no deadtimer
```

Parameters

<1-255>

The keepalive dead interval in seconds. The default value is 120 seconds (4 times the [keepalive \(page 1210\)](#) default value).

Default

120 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#deadtimer 98
```

debug pcep

Use this command to debug PCEP.

Use the `no` form of this command to disable debugging.

Command Syntax

```
debug pcep (events|error|packet|timer|update|report|request|instantiation|delegation|all)
no debug pcep (events|error|packet|timer|update|report|request|instantiation|delegation|all)
```

Parameters

events

Path computation client FSM events

error

Path computation client errors

packet

Path computation client packets

timer

Path computation client timers

update

Path computation update

report

Path computation report

request

Path computation request

instantiation

Path computation instantiation

delegation

Path computation delegation

all

Enable all debugging

Command Mode

Exec and Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#debug pcep packet
#no debug packet
```

exit-capability

Use this command to exit PCEP capability mode.

Command Syntax

```
exit-capability
```

Parameters

None

Command Mode

PCEP capability mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce configuration 1
(config-pcep)#capability
(config-pcep-cap)#exit-capability
(config-pcep)#
```

flap-limit

Use this command to set the number of flaps within the given time unit allowed by a PCE.

Use the `no` form of this command to set the number of flaps and time unit to their default value (0 flaps and 0 seconds).

Command Syntax

```
flap-limit <10-1000> <10-36000>  
no flap-limit
```

Parameters

<10-1000>

Number of flaps allowed by PCE

<10-36000>

Time unit for flap dampening in seconds

Default

Number of flaps: 0

Time unit for flap dampening: 0 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#flap-limit 3 50
```

keepalive

Use this command to set the local keepalive interval.

Use the `no` form of this command to set the keepalive interval to its default (30 seconds).

Command Syntax

```
keepalive <0-255>  
no keepalive
```

Parameters

<0-255>

Keepalive interval in seconds. The default value is 30 seconds.

Default

30 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#keepalive 200
```

lsp-state-timeout

Use this command to set the interval in seconds that a Path Computation Client (PCC) waits when a PCEP session is terminated before flushing the LSP state associated with that PCEP session.

Use the `no` form of this command set the interval to its default value (60 seconds).

Command Syntax

```
lsp-state-timeout (<1-600> | infinity)
no lsp-state-timeout
```

Parameters

<1-600>

Interval in seconds that a PCC waits when a PCEP session is terminated before flushing the LSP state. The default is 60 seconds.

infinity

Maintain state infinitely.

Default

60 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce configuration 127
(config-pcep)#lsp-state-timeout 10
```

pce configuration

Use this command to enter PCEP configuration mode and configure a PCEP client.

Use the `no` form of the command to remove a PCEP client configuration.

Command Syntax

```
pce configuration <1-255>  
no pce configuration <1-255>
```

Parameters

<1-255>

Path computation element entity identifier

Command Mode

Config mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 10  
(config-pcep)#
```

pce init-lsp-limit

Use this command to set the number of PCE initiate messages that a PCC can process.

Use the `no` form of the command to set the number of PCE initiate messages to its default value (1048575 initiate messages).

Command Syntax

```
pce init-lsp-limit <1-1048575>
no pce init-lsp-limit
```

Parameters

<1-1048575>

Number of PCE initiate messages that a PCC can process. The default is 1048575 initiate messages.

Default

1048575 initiate messages

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce init-lsp-limit 7777
```

pce instantiation

Use this command to enable PCE-initiated LSP instantiation.

Use the `no` form of this command to disable PCE-initiated LSP instantiation.

Command Syntax

```
pce instantiation
no pce instantiation
```

Parameters

None

Default

PCE-initiated LSP instantiation is disabled.

Command Mode

PCEP capability mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce configuration 1
(config-pcep)#capability
(config-pcep-cap)#pce instantiation
```

peer-address

Use this command to configure the MD5 authentication key and delegation priority for the session.

Use the `no` form of the command to unset MD5 authentication key.

Command Syntax

```
peer-address ipv4 (A.B.C.D | X:X::X:X) (md5 WORD | delegation-priority <1-65535>|)  
no peer-address ipv4 A.B.C.D (md5 | delegation-priority |)
```

Parameter

A.B.C.D

IPv4 address of the peer

X:X::X:X

IPv6 address of the peer

WORD

The MD5 authentication key

<1-65535>

Delegation priority of the PCEP peer

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#peer-address ipv4 1.1.1.1 md5 ipi-pcep  
  
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#peer-address ipv4 1.1.1.1 delegation-priority 500
```

redelegation-timeout

Use this command to set the timeout in seconds for how long a Path Computation Client (PCC) waits before revoking LSP delegation to a PCE and attempting to redelegate LSPs associated with the terminated PCEP session to an alternate PCE.

Use the `no` form of this command to set the redelegation timeout to its default (30 seconds).

Command Syntax

```
redelegation-timeout <1-600>  
no redelegation-timeout
```

Parameters

<1-600>

Interval in seconds for how long a PCC waits before revoking LSP delegation to a PCE. The default is 30 seconds.

Default

30 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#redelegation-timeout 100
```

request-timeout

Use this command to set the amount of time a Path Computation Client (PCC) waits for a reply after sending a path computation request.

Use the `no` form of this command to the request timeout to its default (10 seconds).

Command Syntax

```
request-timeout <1-20>  
no request-timeout
```

Parameters

<1-20>

Timeout interval for a pending request. The default value is 10 seconds.

Command Mode

10 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#request-timeout 15
```

show pcep client

Use this command to display information about the PCEP client.

Command Syntax

```
show pcep client
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show pcep client

PCEP Client ID
Socket
Service
String
Message received
connection time
```

show pcep detail

Use this command to display all of the session parameters.

Command Syntax

```
show pcep detail
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show pcep detail

=====
Path Computation Client Parameter Details :
=====

Open wait Timer value      : 60 sec
Keep wait Timer value      : 60 sec
Session Connect Timer     : 60 sec
Session Connect Retry      : 5
Keep alive Timer value     : 30 sec
Dead Timer value           : 120 sec
Request Time out value     : 120 sec
                           PCE Initiate LSP's Limit : 1048575
```

show pcep pce-request

Use this command to display the requests in PCEPD module and their status. This command also displays any error messages if the reply received is not correct.

Command Syntax

```
show pcep pce-request
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show pcep pce-request

=====
Path Computation Client Request Details :
=====
Tunnel-id           : 1
Request-id : 1
Ingress              : 1.1.1.1
Egress               : 3.3.3.3
Bandwidth            : 40m
Time due             : 0 secs
State                : In-Progress
```


show pcep peer

Use this command to display all PCE peers and their current states.

Command Syntax

```
show pcep peer
```

Parameters

None

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show pcep peer
=====
Path Computation Client Connection Details :
PCEP entity id : 1
Peer Info
-----
PCE Server IP           : 20.0.0.3
PCEP Local session-id   : 17
PCEP Remote session-id  : 1
Session Connect Retry   : 0
Session Connect due in  : 57 sec
OpenRetry               : 0
Open wait due in        : 0 sec
Keep wait due in        : 0 sec
Keep alive timer due in : 27 sec
Peer Keep-alive value    : 30 sec
Peer Dead timer value    : 120 sec
Peer Dead timer due in   : 117 sec
Peer Overloaded          : No
Peer Overload due in     : 0 sec
LocalOK                  : 1
RemoteOK                 : 1
Max unknown messages     : 0
FSM State                : Up
Total FSM State changes  : 4
Peer Up time             : 00:00:03
Flap Limit Timer value   : 300 Sec
Local Capabilities :
Stateful PCE Capability : Yes
LSP Instantiation      : Yes
SR PCE Capability      : Yes
Remote Capabilities :
Stateful PCE Capability : Yes
LSP Update Capability  : Yes
LSP Instantiation      : Yes
SR PCE Capability      : Yes
#
```

show pcep segment-routing srv6 path brief

Use this command to show as a list the srv6 paths processed by the Path Computation Client (PCC) with the help of an external Path Computation Element (PCE).

Command Syntax

```
show pcep segment-routing srv6 path brief
```

Parameters

None

Command Mode

Exec and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 6.0.0.

Example

```
#sh pcep segment-routing srv6 path brief
```

PCEP Entity : 1 Database

Policy	CP	PLSP-ID	Oper	Admin	Report	Delegated	PCE	Local-Policy	
Redelegation State-timeout									
Name	ID	per lsp	Status	Status	Enabled	PCE	Initiated	Status	in
secs	in secs								
policy1	0	1	UP	UP	Yes	10.8.8.8	Yes	No	NA
NA									

show pcep statistics

Use this command to display the session statistics.

Command Syntax

```
show pcep statistics
```

Parameters

none

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show pcep statistics

=====
Path Computation Client Statistics Details:
=====

Entity Index          : 1
PCE Server IP         : 50.50.50.1
Open sent             : 2
Open rcv              : 1
Path request sent     : 1
Path response rcv     : 1
Error Sent            : 0
Error received        : 0
Notification Sent     : 0
Notification received : 0
Keepalive Sent        : 33
Keepalive received    : 32
Unknown rcv           : 0
Corrupt rcv           : 0
Request cancelled     : 0
Request rejected      : 0
Request Timed out     : 0
Request comp failed   : 0
Request with reply    : 0
```

show pcep tunnel

Use this command to display information about the PCEP tunnels.

Command Syntax

```
show pcep tunnel brief
show pcep tunnel all
show pcep tunnel <5001-65535> pce <1-255>
```

Parameters

brief

Brief information

all

All tunnels

<5001-65535>

Path computation element tunnel identifier

<1-255>

Path computation element entity identifier

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show pcep tunnel brief

PCEP Entity : 1 Database

Tunnel      Tunnel      Oper   Admin   Report   Delegated   PCE      Local-Policy Redefinition
State timeout

Name        ID          LSP-ID   Status  Status  Enabled   PCE      Initiated   Status      in
secs        in secs

=====
t3          5004        2206     UP      UP      Yes       20.0.0.3   No          No          NA
NA

#
```

tolerance deadtimer

Use this command to set the tolerance dead-timer.

Use the `no` form of this command to set the tolerance dead-timer to its default (0 seconds)

Command Syntax

```
tolerance deadtimer <1-255>  
no tolerance deadtimer
```

Parameters

<1-255>

Tolerance dead-timer interval. The default is 0 seconds.

Default

0 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#tolerance deadtimer 50
```

tolerance keepalive

Use this command to set the tolerance keepalive interval.

Use the `no` form of this command to set the tolerance keepalive interval to its default (0 seconds).

Command Syntax

```
tolerance keepalive <1-255>  
no tolerance keepalive
```

Parameters

<1-255>

Tolerance keepalive interval. The default is 0 seconds.

Default

0 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 127  
(config-pcep)#tolerance keepalive 50
```

tunnel-select-policy

Use this command to set tunnel-policy for a VRF 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

VRF mode

Applicability

This command was introduced in OcNOS version 5.1.

Example

```
#configure terminal  
(config)#ip vrf vrf1  
(config-vrf)#tunnel-select-policy p1  
(config-vrf)#commit  
(config-vrf)#  
(config)#ip vrf vrf1  
(config-vrf)#no tunnel-select-policy  
(config-vrf)#commit  
(config-vrf)#
```

update-limit

Use this command to set the number of updates within the given time unit allowed by a PCE.

Use the `no` form of this command to set the number of updates and time unit to their default value (0 flaps and 0 seconds).

Command Syntax

```
update-limit <1-1000> <10-36000>  
no update-limit
```

Parameters

<1-1000>

Number of updates allowed by PCE

<10-36000>

Time unit in seconds for update dampening

Default

Number of updates: 0

Time unit for update dampening: 0 seconds

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#pce configuration 1  
(config-pcep)#update-limit 3 50
```

update-source

Use this command to set the source address for Path Computation Client (PCC) updates.

Use the `no` form of the command to delete the source address for PCC updates.

Command Syntax

```
update-source (A.B.C.D | X:X::X:X)
no update-source
```

Parameters

A.B.C.D

IPv4 source address of the PCC

X:X::X:X

IPv6 source address of the PCC

Default

The source address is null.

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce configuration 10
(config-pcep)#update-source 20.0.0.1
```

Egress Peer Engineering Commands

This chapter describes the egress peer engineering (EPE) commands:

egress-engineering

Use this command to enable EPE for the default BGP routing instance and change the mode to EPE configure mode.

Command Syntax

```
egress-engineering
no egress-engineering
```

Command Mode

Configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Example

```
R1(config)#router bgp 200
R1(config-router)#egress-engineering
R1(config-router-epe)

R1(config-router)#no egress-engineering
```

neighbor peer-adj hop-address

Use this command to allocate an EPE peer-adj SID for a EBGp neighbor via a specific interface and advertise the label to the link-state peer.

Command Syntax

```
neighbor A.B.C.D peer-adj hop-address A.B.C.D  
no neighbor A.B.C.D peer-adj hop-address A.B.C.D
```

Parameters

A.B.C.D

EBGP peer

hop-address

Next-hop address of the specific interface.

Command Mode

EPE configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Example

```
R1(config)#router bgp 200  
R1(config-router)#neighbor 12.1.1.2 remote-as 100  
R1(config-router)#address-family ipv4 unicast  
R1(config-router-af)#neighbor 12.1.1.2 activate  
R1(config-router)#egress-engineering  
R1(config-router-epe)#neighbor 12.1.1.2 peer-node  
R1(config-router-epe)#neighbor 12.1.1.2 peer-adj hop-address 12.1.1.2  
R1(config-router-epe)#no neighbor 12.1.1.2 peer-adj hop-address 12.1.1.2
```

neighbor peer-adj hop-address backup

Use this command to allocate EPE backup for Peer-adj SID for a EBGp neighbor and advertise the label to Link-state peer.

Command Syntax

```
neighbor A.B.C.D peer-adj hop-address A.B.C.D backup backup-type peer-node backup-peer P.Q.R.S
neighbor A.B.C.D peer-adj hop-address A.B.C.D backup backup-type peer-adj backup-peer P.Q.R.S hop-
address P.Q.R.S
no neighbor A.B.C.D peer-node backup
```

Parameters

A.B.C.D

EBGP peer

hop-address

Nexthop address of the specific interface.

backup-type

peer-node and peer-adj

P.Q.R.S

Backup peer for this peer-node sid

Command Mode

EPE configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Example

```
R1(config)#router bgp 200
R1(config-router)#neighbor 12.1.1.2 remote-as 100
R1(config-router)#neighbor 13.1.1.2 remote-as 100
R1(config-router)#address-family ipv4 unicast
R1(config-router-af)#neighbor 12.1.1.2 activate
R1(config-router-af)#neighbor 13.1.1.2 activate
R1(config-router)#egress-engineering
R1(config-router-epe)#neighbor 12.1.1.2 peer-node
R1(config-router-epe)#neighbor 13.1.1.2 peer-node
R1(config-router-epe)#neighbor 12.1.1.2 peer-adj hop-address 12.1.1.2
R1(config-router-epe)#neighbor 13.1.1.2 peer-adj hop-address 13.1.1.2
R1(config-router-epe)#neighbor 12.1.1.2 peer-adj hop-address 12.1.1.2 backup backup-type peer-node
backup-peer 13.1.1.2
R1(config-router-epe)#no neighbor 12.1.1.2 peer-adj hop-address 12.1.1.2 backup
```

For Configuring peer-adj as backup:

```
R1(config-router-epe)#neighbor 12.1.1.2 peer-adj hop-address 12.1.1.2 backup backup-type peer-adj
backup-peer 13.1.1.2 hop-address 13.1.1.2
```

neighbor peer-node

Use this command to allocate EPE peer-node SID for a EBGp neighbor and advertise the label to link-state peer.

Command Syntax

```
neighbor A.B.C.D peer-node  
no neighbor A.B.C.D peer-node
```

Parameters

A.B.C.D

EBGP peer

Command Mode

EPE configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Example

```
R1(config)#router bgp 200  
R1(config-router)#neighbor 12.1.1.2 remote-as 100  
R1(config-router)#address-family ipv4 unicast  
R1(config-router-af)#neighbor 12.1.1.2 activate  
R1(config-router)#egress-engineering  
R1(config-router-epe)#neighbor 12.1.1.2 peer-node  
R1(config-router-epe)#no neighbor 12.1.1.2 peer-node
```

neighbor peer-node backup

Use this command to allocate an EPE backup for a peer-node SID for an EBGp neighbor and advertise the label to the link-state peer.

Command Syntax

```
neighbor A.B.C.D peer-node backup backup-type peer-node backup-peer P.Q.R.S
neighbor A.B.C.D peer-node backup backup-type peer-adj backup-peer P.Q.R.S hop-address P.Q.R.S
no neighbor A.B.C.D peer-node backup
```

Parameters

A.B.C.D

EBGP peer

backup-type

peer-node and peer-adj

P.Q.R.S

Backup peer for this peer-node sid

hop-address

Nexthop address of the specific interface.

Command Mode

EPE configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Example

```
R1(config)#router bgp 200
R1(config-router)#neighbor 12.1.1.2 remote-as 100
R1(config-router)#neighbor 13.1.1.2 remote-as 100
R1(config-router)#address-family ipv4 unicast
R1(config-router-af)#neighbor 12.1.1.2 activate
R1(config-router-af)#neighbor 13.1.1.2 activate
R1(config-router)#egress-engineering
R1(config-router-epe)#neighbor 12.1.1.2 peer-node
R1(config-router-epe)#neighbor 13.1.1.2 peer-node
R1(config-router-epe)#neighbor 12.1.1.2 peer-node backup backup-type peer-node backup-peer 13.1.1.2
R1(config-router-epe)#neighbor 13.1.1.2 peer-adj hop-address 13.1.1.2
R1(config-router-epe)#no neighbor 12.1.1.2 peer-node backup
```

For Configuring peer-adj as backup:

```
R1(config-router-epe)#neighbor 12.1.1.2 peer-node backup backup-type peer-adj backup-peer 13.1.1.2
hop-address 13.1.1.2
```

neighbor peer-set

Use this command to allocate an EPE peer-set SID for a an EBGp neighbor and advertise the label to the link-state peer.

Command Syntax

```
neighbor A.B.C.D peer-set NAME
no neighbor A.B.C.D peer-set NAME
```

Parameters

A.B.C.D

EBGP peer

NAME

Peer set name

Command Mode

EPE configure mode

Applicability

This command was introduced in OcNOS version 5.0.

Example

```
R1(config)#router bgp 200
R1(config-router)#neighbor 12.1.1.2 remote-as 100
R1(config-router)#neighbor 13.1.1.2 remote-as 100
R1(config-router)#address-family ipv4 unicast
R1(config-router-af)#neighbor 12.1.1.2 activate
R1(config-router-af)#neighbor 13.1.1.2 activate
R1(config-router)#egress-engineering
R1(config-router-epe)#neighbor 12.1.1.2 peer-node
R1(config-router-epe)#neighbor 13.1.1.2 peer-node
R1(config-router-epe)#neighbor 12.1.1.2 peer-set EPE
R1(config-router-epe)#neighbor 13.1.1.2 peer-set EPE
R1(config-router-epe)#no neighbor 12.1.1.2 peer-set EPE
```

BGP Link State Distribution Commands

BGP Link State distribution is achieved by retrieving the Link state and traffic engineering information from OSPF and advertising it through Network Layer Reachability Information (NLRI) messages with well-defined TLVs and dedicated address families, called Link States.

BGP Link state capability is a means to collect link state information from OSPF protocol and organizing it into Node, Link, and Prefix NLRIs, and then advertising them to a BGP speaker connected to an external application, such as Path Computation Elements (PCE).

address-family

Use this command to advertise BGP link-state capability to BGP peers.

Use the `no` form of this command to not advertise BGP link-state capability to BGP peers.

Command Syntax

```
address-family link-state link-state
```

Parameters

None

Command Mode

BGP router mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#router bgp 100
(config-router)#neighbor 3.3.3.3 update-source lo
(config-router)#neighbor 3.3.3.3 remote-as 100

(config-router)#address-family link-state link-state
(config-router-af)#neighbor 3.3.3.3 activate
(config-router-af)#exit-address-family
```

debug bgp link-state

Use this command to enable debug logs for BGP link-state distribution.

Use the `no` form of this command to disable debug logs for BGP link-state distribution.

Command Syntax

```
debug bgp link-state  
no debug bgp link-state
```

Parameters

None

Command Mode

Exec and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#debug bgp link-state
```

debug ip ospf dist-ls

Use this command to enable debug logs for OSPF link-state distribution.

Use the `no` form of this command to disable debug logs for OSPF link-state distribution.

Command Syntax

```
debug ip ospf dist-ls
no debug ip ospf dist-ls
```

Parameters

None

Command Mode

Exec and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#debug ip ospf dist-ls
```

debug isis dist-ls

Use this command to enable debug logs for ISIS link-state distribution.

Use the `no` form of this command to disable debug logs for ISIS link-state distribution.

Command Syntax

```
debug isis dist-ls
no debug isis dist-ls
```

Parameters

None

Command Mode

Exec and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#
debug isis dist-ls
```

distribute bgp-ls

Use this command to enable BGP link-state capability in an OSPF or ISIS router instance.

Use the `no` form of this command to disable BGP link-state capability in an OSPF or ISIS router instance.

Command Syntax

```
distribute bgp-ls (throttle <5-20>|)  
no distribute bgp-ls (throttle |)
```

Parameters

<5-20>

Throttle time in seconds to process link-state distribution queue. The default is 5 seconds.

Default

BGP link-state capability is disabled. The default throttle time is 5 seconds.

Command Mode

OSPF router mode

ISIS router mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal  
(config)#router ospf  
(config-ospf)#distribute bgp-ls throttle 10  
(config-ospf)#exit  
  
#configure terminal  
(config)#router isis  
(config-ospf)#distribute bgp-ls throttle 10  
(config-ospf)#exit
```

show bgp link-state

Use this command display the Link State information advertised by BGP.

Command Syntax

```
show bgp link-state (NLRI|self-originate|adv-router A.B.C.D|count|)
```

Parameters

NLRI

NLRI string

self-originated

Self-originated link-state

adv-router

Advertised link-state

A.B.C.D

Advertised router ID

count

Number of NLRI's

Command Mode

Exec and Privileged Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#debian-x86_64#show bgp link-state link-state
BGP router identifier 192.168.0.2, local AS number 100
Origin codes: i - IGP, e - EGP
Prefix codes: E link, V node, T IP reachable route, I Identifier
               N local node, R remote node, L link, P prefix
               L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,
               c confed-ID/ASN, b bgp-identifier, r router-ID,
               i if-address, n nbr-address, o OSPF Route-type,
               p IP-prefix d designated router address
[V] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192.168.0.1]]/216
[V] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192.168.0.2]]/216
[V] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192.168.0.2d25.0.0.2]]/248
[V] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192.168.0.2d35.0.0.1]]/248
[V] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192.168.0.3]]/216
i [V] [O] [I0xa] [N[c100] [b192.168.0.3] [a0.0.0.0] [r192.168.0.1]]/216
i [V] [O] [I0xa] [N[c100] [b192.168.0.3] [a0.0.0.0] [r192.168.0.2]]/216
i [V] [O] [I0xa] [N[c100] [b192.168.0.3] [a0.0.0.0] [r192.168.0.2d25.0.0.2]]/248
i [V] [O] [I0xa] [N[c100] [b192.168.0.3] [a0.0.0.0] [r192.168.0.2d35.0.0.1]]/248
i [V] [O] [I0xa] [N[c100] [b192.168.0.3] [a0.0.0.0] [r192.168.0.3]]/216
[E] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192.168.0.1] [R[c100] [b192.168.0.2] [a0.0.0.0]
[r192.168.0.2d25.0.0.2]] [L[i25.0.0.1]
[n25.0.0.2]]/376
[E] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192.168.0.2] [R[c100] [b192.168.0.2] [a0.0.0.0]
[r192.168.0.2d25.0.0.2]] [L[i25.0.0.2]
```

```

[n25.0.0.2]]/376
[E][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.2][R[c100][b192.168.0.2][a0.0.0.0]
[r192.168.0.2d35.0.0.1]][L[i35.0.0.1]
[n35.0.0.1]]/376
[E][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.2d25.0.0.2][R[c100][b192.168.0.2][a0.0.0.0]
[r192.168.0.1]][L[i25.0.0.2]
[n25.0.0.1]]/376
[E][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.2d25.0.0.2][R[c100][b192.168.0.2][a0.0.0.0]
[r192.168.0.2]][L[i25.0.0.2]
[n25.0.0.2]]/376
[E][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.2d35.0.0.1][R[c100][b192.168.0.2][a0.0.0.0]
[r192.168.0.2]][L[i35.0.0.1]
[n35.0.0.1]]/376
[E][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.2d35.0.0.1][R[c100][b192.168.0.2][a0.0.0.0]
[r192.168.0.3]][L[i35.0.0.1]
[n35.0.0.2]]/376
[E][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.3][R[c100][b192.168.0.2][a0.0.0.0]
[r192.168.0.2d35.0.0.1]][L[i35.0.0.2]
[n35.0.0.1]]/376
i [E][O][I0xa][N[c100][b192.168.0.3][a0.0.0.0][r192.168.0.2d25.0.0.2][R[c100][b192.168.0.3][a0.0.0.0]
[r192.168.0.1]][L[i25.0.0.2]
[n25.0.0.1]]/376
i [E][O][I0xa][N[c100][b192.168.0.3][a0.0.0.0][r192.168.0.2d25.0.0.2][R[c100][b192.168.0.3][a0.0.0.0]
[r192.168.0.2]][L[i25.0.0.2]
[n25.0.0.2]]/376
i [E][O][I0xa][N[c100][b192.168.0.3][a0.0.0.0][r192.168.0.2d35.0.0.1][R[c100][b192.168.0.3][a0.0.0.0]
[r192.168.0.2]][L[i35.0.0.1]
[n35.0.0.1]]/376
[T][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.1]][P[0x1][p192.168.0.1/32]]/264
[T][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.2]][P[0x1][p192.168.0.2/32]]/264
[T][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.3]][P[0x1][p192.168.0.3/32]]/264
i [T][O][I0xa][N[c100][b192.168.0.3][a0.0.0.0][r192.168.0.1]][P[0x1][p192.168.0.1/32]]/264
i [T][O][I0xa][N[c100][b192.168.0.3][a0.0.0.0][r192.168.0.2]][P[0x1][p192.168.0.2/32]]/264
i [T][O][I0xa][N[c100][b192.168.0.3][a0.0.0.0][r192.168.0.3]][P[0x1][p192.168.0.3/32]]/264
NLRIs, Total: 27, Node: 10, Link: 11, Prefix: 6

```

```

debian-x86_64#show bgp link-state link-state count

```

```

-----
Total   NLRIs   : 16
Node    NLRIs   : 5
Link    NLRIs   : 8
Prefix  NLRIs   : 3
-----

```

```

debian-x86_64#show bgp link-state link-state adv-router 192.168.0.3

```

```

BGP router identifier 192.168.0.2, local AS number 100

```

```

Origin codes: i - IGP, e - EGP

```

```

Prefix codes: E link, V node, T IP reachable route, I Identifier

```

```

N local node, R remote node, L link, P prefix

```

```

L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,

```

```

c confed-ID/ASN, b bgp-identifier, r router-ID,

```

```

i if-address, n nbr-address, o OSPF Route-type,

```

```

p IP-prefix d designated router address

```

```

[V][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.3]]/216

```

```

[E][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.3][R[c100][b192.168.0.2][a0.0.0.0]
[r192.168.0.2d35.0.0.1]][L[i35.0.0.2]
[n35.0.0.1]]/376

```

```

[T][O][I0xa][N[c100][b192.168.0.2][a0.0.0.0][r192.168.0.3]][P[0x1][p192.168.0.3/32]]/264

```

```

NLRIs, Total: 3, Node: 1, Link: 1, Prefix: 1

```

```

debian-x86_64#show bgp link-state link-state self-originate

```

```

BGP router identifier 192.168.0.2, local AS number 100

```

```

Origin codes: i - IGP, e - EGP

```

```

Prefix codes: E link, V node, T IP reachable route, I Identifier

```

```

N local node, R remote node, L link, P prefix

```

```

L1/L2 ISIS level-1/level-2, O OSPF, a area-ID,

```

```

c confed-ID/ASN, b bgp-identifier, r router-ID,

```

```

i if-address, n nbr-address, o OSPF Route-type,

```

```

p IP-prefix d designated router address

```

```
[V] [O] [I0xa] [N[c100] [b192.168.0.2] [a0.0.0.0] [r192
```

PCEP Segment-Routing Commands

This section describes the segment routing commands for Path Computation Element Protocol (PCEP).

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.



Note: In case of segment-routing policy, when delegation is revoked, OcNOS (PCC) continues to use the current Explicit Route Object (ERO) if it is available. If the ERO is unavailable, the LSP state remains down. In both cases, the system will simultaneously initiate a new Path Computation Request (PCReq) packet to the Path Computation Element (PCE) to obtain an updated path.

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
```

segment-routing pcep

Use this command to enable segment routing for PCE.

Use the `no` form of this command to disable the segment-routing.

Command Syntax

```
segment-routing pcep
no segment-routing pcep
```

Parameters

None

Command Mode

PCEP mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#configure terminal
(config)#pce configuration 1
(config-pcep)#capability
(config-pcep-cap)#segment-routing pcep
```

show pcep segment-routing lsp

Use this command to display information about PCEP segment routing tunnels.

Command Syntax

```
show pcep segment-routing lsp brief
show pcep segment-routing lsp <1-1048575> pce <1-255>
```

Parameters

<1-1048575>

LSP identifier

<1-255>

Path computation element entity identifier

brief

Brief information

Command Mode

Exec mode

Applicability

This command was introduced in OcNOS version 4.0.

Example

```
#show pcep segment-routing lsp 1 pce 1
=====
Tunnel ID : 1
PCEP Entity : 1
Request ID : 0
SRP ID : 0
Tunnel Name : p1
Symbolic Pathname : SR_LSP_1
Admin Status : UP
PCEP Peer : 20.0.0.3
PLSP-ID : 1
CP-ID : 12
Source Address : 1.1.1.1
Destination Address : 2.2.2.2
Extended Tunnel ID : 0.0.0.0
Tunnel Type : NSM SR Policy
PCEP Tunnel Delegate State : Delegation Enabled
PCEP Tunnel Report State : Report Enabled
PCE Initiated : No
Tunnel FSM Recent Event : New Session UP
Request Flag : None Set
Error Flag : None Set
Number of LSPs : 1
LSP ID : 0
Binding value info :
Binding value : 25600
Owner : PCC (local policy)
Alloc Mode : DYNAMIC
Oper Status : UP
```

```
SR ERO Hop Count : 1
SR ERO Hops :
Segment Type : 1
SID Label : 16002
SR RRO Hop Count : 1
SR RRO Hops :
Segment Type : 1
SID Label : 16002
Pending Updates : No pending updates
```