

Configuring Segment Routing

This chapter contains information on how to configure segment routing.

- About Segment Routing, on page 1
- Guidelines and Limitations for Segment Routing, on page 3
- Configuring Segment Routing, on page 6
- Configuring Segment Routing with IS-IS Protocol, on page 17
- Configuring Segment Routing with OSPFv2 Protocol, on page 18
- Configuring Segment Routing for Traffic Engineering, on page 24
- Configuring SR-TE Manual Preference Selection, on page 36
- Configuring SRTE Flow-based Traffic Steering, on page 40
- Configuring MPLS OAM Monitoring for SRTE Policies, on page 56
- Configuring Egress Peer Engineering with Segment Routing, on page 66
- Configuring Layer2 EVPN over Segment Routing MPLS, on page 73
- Configuring Proportional Multipath for VNF for Segment Routing, on page 86
- vPC Multihoming, on page 88
- Configuring Layer 3 EVPN and Layer 3 VPN over Segment Routing MPLS, on page 90
- Configuring Segment Routing MPLS and GRE Tunnels, on page 103
- Verifying SR-TE for Layer 3 EVPN, on page 106
- Verifying the Segment Routing Configuration, on page 107
- Configuring SRTE Explicit-Path Endpoint Substitution, on page 109
- Configuring SRTE Over Default VRF, on page 113
- Additional References, on page 130

About Segment Routing

Segment routing is a technique by which the path followed by a packet is encoded in the packet itself, similar to source routing. A node steers a packet through a controlled set of instructions, called segments, by prepending the packet with a segment routing header. Each segment is identified by a segment ID (SID) consisting of a flat unsigned 32-bit integer.

Border Gateway Protocol (BGP) segments, a subclass of segments, identify a BGP forwarding instruction. There are two groups of BGP segments: prefix segments and adjacency segments. Prefix segments steer packets along the shortest path to the destination, using all available equal-cost multi-path (ECMP) paths.

Adjacency segments steer packets onto a specific link to a neighbor.

The segment routing architecture is applied directly to the MPLS data plane.

Segment Routing Application Module

Segment Routing Application (SR-APP) module is used to configure the segment routing functionality. Segment Routing Application (SR-APP) is a separate internal process that handles all the CLIs related to segment routing. It is responsible for reserving the SRGB range and for notifying the clients about it. It is also responsible for maintaining the prefix to SID mappings. The SR-APP support is also available for the BGP, IS-IS, and OSPF protocols.

The SR-APP module maintains the following information:

- · Segment routing operation state
- Segment routing global block label ranges
- Prefix SID mappings

For more information, see Configuring Segment Routing, on page 6.

NetFlow for MPLS

NetFlow identifies packet flows for ingress IP packets and provides statistics that are based on these packet flows. NetFlow does not require any change to either the packets themselves or to any networking device. You can export the data that NetFlow gathers for your flow by using a flow exporter and export this data to a remote NetFlow Collector, such as Cisco Stealthwatch. Cisco NX-OS exports flow as part of a NetFlow export User Datagram Protocol (UDP) datagram. You can export the data that NetFlow gathers for your flow by using a flow exporter and export this data to a remote NetFlow Collector, such as Cisco Stealthwatch. Cisco NX-OS exports flow as part of a NetFlow by using a flow exporter and export this data to a remote NetFlow Collector, such as Cisco Stealthwatch. Cisco NX-OS exports a flow as part of a NetFlow export User Datagram Protocol (UDP) datagram.

Beginning with Cisco NX-OS Release 9.3(1), NetFlow Collector over segment routing is supported on Cisco Nexus 9300-EX, 9300-FX, 9300-FX2, 9500-EX, and 9500-FX platform switches.

Beginning with Cisco NX-OS Release 9.3(5), NetFlow Collector over segment routing is supported on Cisco Nexus 9300-FX3 platform switches.

NetFlow is not supported on Cisco Nexus 9300-GX platform switches..

NetFlow Collector supports both, single and double MPLS labels. Both, default and the non-default VRF in the exporter destination configurations is supported. NetFlow does not support an MPLS data path.

Since segment routing does not support a single label, you must configure the **address-family ipv4 labeled-unicast** command under BGP neighbor and the **allocate-label** command under the bgp configuration.

sFlow Collector

Sampled flow (sFlow) allows you to monitor real-time traffic in data networks that contain switches and routers. It uses the sampling mechanism in the sFlow agent software on switches and routers to monitor traffic and to forward the sample data to the central data collector.

Beginning with Cisco NX-OS Release 9.3(1), sFlow collector over segment routing is supported on Cisco Nexus 9300-EX, 9300-FX, 9300-FX2, 9500-EX, and 9500-FX platform switches.

Beginning Cisco NX-OS Release 9.3(5), sFlow collector over segment routing is supported on Cisco Nexus 9300-FX3 platform switches.

sFlow is not supported on Cisco Nexus 9364C-GX, Cisco Nexus 9316D-GX, and Cisco Nexus 93600CD-GX switches.

For information on configuring sFlow, see the *Configuring sFlow* section in the *Cisco Nexus* 9000 Series NX-OS System Management Configuration Guide, Release 9.3(x).

Guidelines and Limitations for Segment Routing

Segment routing has the following guidelines and limitations:

- MPLS segment routing is not supported for FEX modules.
- Beginning with Cisco NX-OS Release 9.3(1), the **segment-routing mpls** command has changed to **segment-routing**.
- When you enable MPLS segment routing on Cisco Nexus 9504 and 9508 platform switches with a -R series line card, there can be instances of the BFD sessions going down and coming back. BGP peerings, if configured with BFD, also go down and come back up. When a BGP session goes down, it withdraws routes from the hardware. This results in packet loss until the BGP session is re-established and routes are re-installed. However, once the BFD comes up, no additional flaps occurs.
- You can run segment routing under IGP(like OSPF) or by AF labeled unicast in BGP.
- Segment Routing is supported on Cisco Nexus 9300-FX platform switches and the Cisco Nexus N9K-X9736C-FX line cards.
- Segment routing and SR-EVPN are supported on Cisco Nexus C31108PC-V, C31108TC-V, and C3132Q-V switches.
- Beginning with Cisco NX-OS Release 9.3(3), you can configure Layer 3 VPNs on Cisco Nexus 9300-GX platform switches.
- Beginning with Cisco NX-OS Release 9.3(3), segment routing and SR-EVPN is supported on Cisco Nexus 9364C-GX, Cisco Nexus 9316D-GX, and Cisco Nexus 93600CD-GX platform switches.
- Beginning with Cisco NX-OS Release 9.3(3), adjacency SIDs on OSPF are supported on Cisco Nexus 9364C-GX, Cisco Nexus 9316D-GX, and Cisco Nexus 93600CD-GX platform switches.
- Beginning with Cisco NX-OS Release 9.3(3), segment routing with OSPF, IS-IS underlay, and BGP labeled unicast is supported on Cisco Nexus 9364C-GX, Cisco Nexus 9316D-GX, and Cisco Nexus 93600CD-GX platform switches.
- BGP allocates the SRGB label for iBGP route-reflector clients only when next-hop-self is in effect (for example, the prefix is advertised with the next hop being one of the local IP/IPv6 addresses on RR). When you have configured next-hop-self on an RR, the next hop is changed for the routes that are being affected (subject to route-map filtering).
- A nondisruptive ISSU is not supported with MPLS features for Cisco Nexus 9300-EX and 9300-FX platform switches.
- Static MPLS, MPLS segment routing, and MPLS stripping cannot be enabled at the same time.
- Beginning with Cisco NX-OS Release 9.3(5), MPLS stripping is supported on Cisco Nexus 9300-GX platform switches and the following guidelines are applicable:

- For the MPLS strip feature to work, both the **mpls strip** and the **hardware acl tap-agg** commands should be configured after the switches are reloaded.
- When the MPLS strip is enabled on the Cisco Nexus 9300-GX platform switches, the ACL log
 process is not displayed.
- MPLS strip with dot1q VLAN is not supported.
- For all double VLAN tags, the second VLAN range should be between 2-510.
- MPLS strip with dot1q is not supported.
- For PACL redirect support, you must use the **mode tap-aggregation** command on the ingress TAP interface.
- Because static MPLS, MPLS segment routing, and MPLS stripping are mutually exclusive, the only segment routing underlay for multi-hop BGP is single-hop BGP. iBGP multi-hop topologies with eBGP running as an overlay are not supported.
- MPLS pop followed by a forward to a specific interface is not supported. The penultimate hop pop (PHP) is avoided by installing the Explicit NULL label as the outlabel in the label FIB (LFIB) even when the control plane installs an IPv4 Implicit NULL label.
- BGP labeled unicast and BGP segment routing are not supported for IPv6 prefixes.
- BGP labeled unicast and BGP segment routing are not supported over tunnel interfaces (including GRE and VXLAN) or with vPC access interfaces.
- MTU path discovery (RFC 2923) is not supported over MPLS label switched paths (LSPs) or segment routed paths.
- For the Cisco Nexus 9200 Series switches, adjacency statistics are not maintained for Layer 3 or MPLS adjacencies.
- For the Cisco Nexus 9500 Series switches, MPLS LSPs and segment routed paths are not supported on subinterfaces (either port channels or normal Layer 3 ports).
- For the Cisco Nexus 9500 platform switches, segment routing is supported only in the nonhierarchical routing mode.
- The BGP configuration commands **neighbor-down fib-accelerate** and **suppress-fib-pending** are not supported for MPLS prefixes.
- The uniform model as defined in RFC 2973 and RFC 3270 is not supported. Therefore, the IP DSCP bits are not copied into the imposed MPLS header.
- Reconfiguration of the segment routing global block (SRGB) results in an automatic restart of the BGP process to update the existing URIB and ULIB entries. Traffic loss occurs for a few seconds, so you should not reconfigure the SRGB in production.
- If the segment routing global block (SRGB) is set to a range but the route-map label-index delta value is outside of the configured range, the allocated label is dynamically generated. For example, if the SRGB is set to range of 16000-23999 when a route-map label-index is set to 9000, the label is dynamically allocated.
- For network scalability, Cisco recommends using a hierarchical routing design with multi-hop BGP for advertising the attached prefixes from a top-of-rack (ToR) or border leaf switch.

- BGP sessions are not supported over MPLS LSPs or segment routed paths.
- The Layer 3 forwarding consistency checker is not supported for MPLS routes.
- You can configure segment routing traffic engineering with on-demand next hop on Cisco Nexus 9000 Series switches.
- Layer 3 VPN and Layer 3 EVPN stitching for segment routing is supported on Cisco Nexus 9000 Series switches.
- Beginning with Cisco NX-OS Release 9.3(3), Layer 3 VPN and Layer 3 EVPN stitching for segment routing is supported on 9300-GX platform switches.
- You can configure OSPFv2 as an IGP control plane for segment routing on Cisco Nexus 9000 Series switches.
- Layer 3 VPN and Layer 3 EVPN Stitching for segment routing is not supported on Cisco Nexus 9364C, 9200, 9300-EX, and 9500 platform switches with the -EX line cards.
- The OSPF segment routing command and segment-routing traffic engineering with on-demand next hop is not supported on Cisco Nexus 9364C switches.
- Segment Routing is supported on Cisco Nexus 9300-FX2 and 9300-FX3 platform switches.
- Layer 3 VPN and Layer 3 EVPN Stitching for Segment Routing, the OSPF segment routing command, and the segment-routing traffic engineering with on-demand next hop is supported on Cisco Nexus 9364C switches.
- Layer 3 VPN over Segment Routing is supported on Cisco Nexus 3100, 3200, 9200, 9300, 9300-EX/FX/FX2/FX3 platform switches and Cisco Nexus 9500 platform switches with -EX/FX and -R line cards.
- Deleting the segment routing configuration removes all the related segment routing configurations including the MPLS and the traffic engineering configurations.
- If you downgrade the Cisco Nexus device from Cisco NX-OS Release 9.3(1) to the previous NX-OS releases by setting the boot variables and reloading the switch, all earlier configurations of the segment-routing MPLS are lost.
- Before performing an ISSD from Cisco NX-OS Release 9.3(1), you must disable the segment routing configuration. Failure to do so will result in the loss of the existing segment routing configurations.
- Segment routing MPLS adjacency statistics are collected based on the out label stack and the next hop on the intermediate nodes. However, in the PHP mode, the statistics are shown on all adjacencies because the same stack is shared on all the FECs.
- If segment routing is enabled on a switch, Q-in-Q tagging on a dot1Q tagged MPLS packet is not supported, packets egress with only the outer tag.

For example: Consider an ingress port in access dot1q tunnel mode, with VLAN 100. Incoming MPLS traffic has a dot1Q tag of 200. Typically, the traffic should egress with an outer tag of 100, and inner tag of 200 (same as the tag of the incoming packet). However, the packet egresses with an outer tag and loses the inner tag.

• When an incoming MPLS packet is untagged and the ingress port is in access VLAN mode, packets egress without any tag, if segment routing is enabled.

- We recommend that you do not configure segment routing using BGP, OSPF, and IS-IS underlay simultaneously.
- Beginning with Cisco NX-OS Release 10.2(1q)F, SR-MPLS is supported on the N9K-C9332D-GX2B platform switches. However, SR PBR and MPLS strip dot1q features are not yet supported on GX2 switches.

Configuring Segment Routing

Configuring Segment Routing

Before you begin

Confirm that the following conditions are met before configuring segment routing.

- The **install feature-set mpls**, **feature-set mpls** and **feature mpls segment-routing** commands should be present before configuring the **segment-routing** command.
- If the global block is configured, the specified range is used. Otherwise, the default 16000 23999 range is used.
- BGP now uses both **set label-index** *<value>* configuration and the new **connected-prefix-sid-map** CLI. In case of a conflict, the configuration in SR-APP is preferred.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	segment-routing	Enables the MPLS segment routing
	Example:	functionality. The no form of this command disables the MPLS segment routing feature.
	<pre>switch(config)# segment-routing switch(config-sr)# mpls switch(config-sr-mpls)#</pre>	
Step 3	connected-prefix-sid-map	Configures the connected prefix segment
	Example:	identifier mappings.
	<pre>switch(config-sr-mpls)# connected-prefix-sid-map switch(config-sr-mpls)#</pre>	
Step 4	global-block <min> <max></max></min>	Specifies the global block range for the segment
	Example:	routing bindings.

	Command or Action	Purpose
	<pre>switch(config-sr-mpls)# global-block <min> <max> switch(config-sr-mpls)#</max></min></pre>	
Step 5	connected-prefix-sid-map	Configures the connected prefix segment
	Example:	identifier mappings.
	<pre>switch(config-sr-mpls)# connected-prefix-sid-map switch(config-sr-mpls-conn-pfsid)#</pre>	
Step 6	address-family ipv4	Configures the IPv4 address family.
	Example:	
	<pre>switch(config-sr-mpls-conn-pfsid)#address-family ipv4</pre>	
Step 7 <prefix>/<masklen> [index absolute] <label> The optional 1 indicate wheth indicate wheth is interpreted an absolute 201101</label></masklen></prefix>	The optional keywords index or absolute	
	indicate whether the label value entered should be interpreted as an index into the SRGB or as	
	<pre>switch(config-sr-mpls)# 2.1.1.5/32 absolute 201101</pre>	an absolute value.

Example

See the following configuration examples of the show commands:

```
switch# show segment-routing mpls
Segment-Routing Global info
Service Name: segment-routing
State: Enabled
Process Id: 29123
Configured SRGB: 17000 - 24999
SRGB Allocation status: Alloc-Successful
Current SRGB: 17000 - 24999
Cleanup Interval: 60
Retry Interval: 180
```

The following CLI displays the clients that are registered with SR-APP. It lists the VRFs, for which the clients have registered interest.

```
switch# show segment-routing mpls clients
    Segment-Routing Mpls Client Info
Client: isis-1
    PIB index: 1 UUID: 0x41000118 PID: 29463 MTS SAP: 412
    TIBs registered:
        VRF: default Table: base
```

```
Client: bgp-1

PIB index: 2 UUID: 0x11b PID: 18546 MTS SAP: 62252

TIBs registered:

VRF: default Table: base

Total Clients: 2
```

In the **show segment-routing mpls ipv4 connected-prefix-sid-map** CLI command example, SRGB indicates whether the prefix SID is within the configured SRGB. The **Indx** field indicates that the configured label is an index into the global block. The **Abs** field indicates that the configured label is an absolute value.

If the SRGB field displays N, it means that the configured prefix SID is not within the SRGB range and it is not provided to the SR-APP clients. Only the prefix SIDs that fall into the SRGB range are given to the SR-APP clients.

```
switch# show segment-routing mpls ipv4 connected-prefix-sid-map
          Segment-Routing Prefix-SID Mappings
Prefix-SID mappings for VRF default Table base
Prefix
             SID Type Range SRGB
               713 Indx 1
730 Indx 1
13.11.2.0/24
                                Y
30.7.7.7/32
                                Y
59.3.24.0/30
               759 Indx 1
                               Y
150.101.1.0/24
               801 Indx 1
                               Y
                               Y
150.101.1.1/32 802 Indx 1
150.101.2.0/24 803
                      Indx 1
                                Υ
1.1.1/32
                16013 Abs 1
                                Υ
```

The following CLI displays the show running-config segment-routing output.

```
switch# show running-config segment-routing ?
> Redirect it to a file
>> Redirect it to a file in append mode
all Show running config with defaults
| Pipe command output to filter
switch# show running-config segment-routing
switch# show running-config segment-routing
!Command: show running-config segment-routing
!Running configuration last done at: Thu Dec 12 19:39:52 2019
!Time: Thu Dec 12 20:06:07 2019
version 9.3(3) Bios:version 05.39
segment-routing
   mpls
        connected-prefix-sid-map
            address-family ipv4
               2.1.1.1/32 absolute 100100
switch#
```

Enabling MPLS on an Interface

You can enable MPLS on an interface for use with segment routing.

Before you begin

You must install and enable the MPLS feature set using the **install feature-set mpls** and **feature-set mpls** commands.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	interface type slot/port	Enters the interface configuration mode for the
	Example:	specified interface.
	<pre>switch(config)# interface ethernet 2/2 switch(config-if)#</pre>	
Step 3	[no] mpls ip forwarding Enables MPLS	Enables MPLS on the specified interface. The
	<pre>Example: switch(config-if)# mpls ip forwarding</pre>	no form of this command disables MPLS on the specified interface.
Step 4	(Optional) copy running-config startup-config	Copies the running configuration to the startup
	Example:	configuration.
	switch(config-if)# copy running-config startup-config	

Configuring the Segment Routing Global Block

You can configure the beginning and ending MPLS labels in the segment routing global block (SRGB).

Before you begin

You must install and enable the MPLS feature set using the **install feature-set mpls** and **feature-set mpls** commands.

You must enable the MPLS segment routing feature.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	

	Command or Action	Purpose
Step 2	<pre>[no] segment-routing Example: switch(config)# segment-routing switch(config-sr)# mpls</pre>	Enters the segment routing configuration mode and enables the default SRGB of 16000 to 23999. The no form of this command unallocates that block of labels.
		If the configured dynamic range cannot hold the default SRGB, an error message appears, and the default SRGB will not be allocated. If desired, you can configure a different SRGB in the next step.
Step 3	<pre>[no] global-block beginning-label ending-label Example: switch(config-sr-mpls)# global-block 16000_471804</pre>	Specifies the MPLS label range for the SRGB. Use this command if you want to change the default SRGB label range that is configured with the segment-routing command.
		The permissive values for the beginning MPLS label and the ending MPLS label are from 16000 to 471804. The mpls label range command permits 16 as the minimum label, but the SRGB can start only from 16000.
		Note The minimum value for the global-block command starts from 16000. If you upgrading from previous releases, you should modify the SRGB so that it falls within the supported range before triggering an upgrade.
Step 4	<pre>(Optional) show mpls label range Example: switch(config-sr-mpls)# show mpls label range</pre>	Displays the SRGB, only if the SRGB allocation is successful.
Step 5	show segment-routing	Displays the configured SRGB.
Step 6	show segment-routing mpls	Displays the configured SRGB.
	<pre>Example: switch(config-sr-mpls)# show segment-routing mpls</pre>	
Step 7	<pre>(Optional) copy running-config startup-config Example: switch(config-sr-mpls)# copy running-config startup-config</pre>	Copies the running configuration to the startup configuration.

Configuring the Label Index

You can set the label index for routes that match the **network** command. Doing so causes the BGP prefix SID to be advertised for local prefixes that are configured with a route map that includes the **set label-index** command, provided the route map is specified in the **network** command that specifies the local prefix. (For more information on the **network** command, see the "Configuring Basic BGP" chapter in the Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide.)

Note

Segment Routing Application (SR-APP) module is used to configure the segment routing functionality. BGP now uses both **set label-index** *<value>* configuration under route-map and the new **connected-prefix-sid-map** CLI for prefix SID configuration. In case of a conflict, the configuration in SR-APP is preferred.



Note Route-map label indexes are ignored when the route map is specified in a context other than the **network** command. Also, labels are allocated for prefixes with a route-map label index independent of whether the prefix has been configured by the **allocate-label route-map** *route-map*-name command.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map map-name	Creates a route map or enters route-map
	Example:	configuration mode for an existing route map.
	<pre>switch(config)# route-map SRmap switch(config-route-map)#</pre>	
Step 3	[no] set label-index index	Sets the label index for routes that match the
	Example:	network command. The range is from 0 to 471788 By default a label index is not added
	<pre>switch(config-route-map)# set label-index 10</pre>	to the route.
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	router bgp autonomous-system-number	Enables BGP and assigns the AS number to the
	Example:	local BGP speaker. The AS number can be a
	<pre>switch(config)# router bgp 64496 switch(config-router)#</pre>	a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.

	Command or Action	Purpose
Step 6	Required: address-family ipv4 unicast	Enters global address family configuration
	Example:	mode for the IPv4 address family.
	<pre>switch(config-router)# address-family ipv4 unicast switch(config-router-af)#</pre>	
Step 7	network ip-prefix [route-map map-name]	Specifies a network as local to this autonomous
	Example:	system and adds it to the BGP routing table.
	<pre>switch(config-router-af)# network 10.10.10.10/32 route-map SRmap</pre>	
Step 8	(Optional) show route-map [map-name]	Displays information about route maps,
	Example:	including the label index.
	<pre>switch(config-router-af)# show route-map</pre>	
Step 9	(Optional) copy running-config startup-config	Copies the running configuration to the startup
	Example:	configuration.
	<pre>switch(config-router-af)# copy running-config startup-config</pre>	

Configuration Examples for Segment Routing

The examples in this section show a common BGP prefix SID configuration between two routers.

This example shows how to advertise a BGP speaker configuration of 10.10.10.10/32 and 20.20.20/32 with a label index of 10 and 20, respectively. It uses the default segment routing global block (SRGB) range of 16000 to 23999.

```
hostname s1
install feature-set mpls
feature-set mpls
feature telnet
feature bash-shell
feature scp-server
feature bgp
feature mpls segment-routing
segment-routing
 mpls
  vlan 1
segment-routing
 mpls
   connected-prefix-sid-map
   address-family ipv4
   2.1.1.1/32 absolute 100100
route-map label-index-10 permit 10
 set label-index 10
route-map label-index-20 permit 10
 set label-index 20
vrf context management
```

L

```
ip route 0.0.0.0/0 10.30.108.1
interface Ethernet1/1
  no switchport
  ip address 10.1.1.1/24
  no shutdown
interface mgmt0
  ip address dhcp
  vrf member management
interface loopback1
  ip address 10.10.10.10/32
interface loopback2
 ip address 20.20.20.20/32
line console
line vty
router bgp 1
  address-family ipv4 unicast
   network 10.10.10.10/32 route-map label-index-10
   network 20.20.20.20/32 route-map label-index-20
   allocate-label all
  neighbor 10.1.1.2 remote-as 2
    address-family ipv4 labeled-unicast
```

This example shows how to receive the configuration from a BGP speaker.

```
hostname s2
install feature-set mpls
feature-set mpls
feature telnet
feature bash-shell
feature scp-server
feature bgp
feature mpls segment-routing
segment-routing mpls
vlan 1
vrf context management
  ip route 0.0.0.0/0 10.30.97.1
  ip route 0.0.0.0/0 10.30.108.1
interface Ethernet1/1
  no switchport
  ip address 10.1.1.2/24
  ipv6 address 10:1:1::2/64
 no shutdown
interface mgmt0
  ip address dhcp
  vrf member management
interface loopback1
  ip address 2.2.2/32
line console
line vty
router bgp 2
```

```
address-family ipv4 unicast
allocate-label all
neighbor 10.1.1.1 remote-as 1
address-family ipv4 labeled-unicast
```

This example shows how to display the configuration from a BGP speaker. The **show** command in this example displays the prefix 10.10.10.10 with label index 10 mapping to label 16010 in the SRGB range of 16000 to 23999.

```
switch# show bgp ipv4 labeled-unicast 10.10.10.10/32
```

```
BGP routing table information for VRF default, address family IPv4 Label Unicast
BGP routing table entry for 10.10.10.10/32, version 7
Paths: (1 available, best #1)
Flags: (0x20c001a) on xmit-list, is in urib, is best urib route, is in HW, , has label
  label af: version 8, (0x100002) on xmit-list
  local label: 16010
 Advertised path-id 1, Label AF advertised path-id 1
  Path type: external, path is valid, is best path, no labeled nexthop, in rib
  AS-Path: 1 , path sourced external to AS
    10.1.1.1 (metric 0) from 10.1.1.1 (10.10.10.10)
      Origin IGP, MED not set, localpref 100, weight 0
      Received label 0
      Prefix-SID Attribute: Length: 10
        Label Index TLV: Length 7, Flags 0x0 Label Index 10
  Path-id 1 not advertised to any peer
  Label AF advertisement
  Path-id 1 not advertised to any peer
```

This example shows how to configure egress peer engineering on a BGP speaker.

```
hostname epe-as-1
install feature-set mpls
feature-set mpls
feature telnet
feature bash-shell
feature scp-server
feature bgp
feature mpls segment-routing
segment-routing mpls
vlan 1
vrf context management
  ip route 0.0.0.0/0 10.30.97.1
  ip route 0.0.0/0 10.30.108.1
interface Ethernet1/1
  no switchport
  ip address 10.1.1.1/24
 no shutdown
interface Ethernet1/2
 no switchport
  ip address 11.1.1.1/24
 no shutdown
interface Ethernet1/3
 no switchport
  ip address 12.1.1.1/24
```

```
no shutdown
interface Ethernet1/4
no switchport
ip address 13.1.1.1/24
no shutdown
interface Ethernet1/5
no switchport
ip address 14.1.1.1/24
no shutdown
```

The following is an example of show ip route vrf 2 command.

```
show ip route vrf 2
IP Route Table for VRF "2"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>
41.11.2.0/24, ubest/mbest: 1/0
    *via 1.11.9%default, [20/0], 13:26:48, bgp-2, external, tag 11 (mpls-vpn)
42.11.2.0/24, ubest/mbest: 1/0, attached
    *via 42.11.2.1, Vlan2, [0/0], 13:40:52, direct
42.11.2.1/32, ubest/mbest: 1/0, attached
    *via 42.11.2.1, Vlan2, [0/0], 13:40:52, local
```

The following is an example of show forwarding route vrf 2 command.

```
slot 1
======
```

IPv4 routes for table 2/base

Prefix Part	Next-hop ial Install	Interface	Labels
0.0.0/32	 Drop	-++++++	
127.0.0.0/8	Drop	NullO	
255.255.255.255/	32 Receive	sup-eth1	
*41.11.2.0/24	27.1.31.4	Ethernet1/3	PUSH
30002 492529			
	27.1.32.4	Ethernet1/21	PUSH
30002 492529			
	27.1.33.4	port-channel23	PUSH
30002 492529			
	27.11.31.4	Ethernet1/3.11	PUSH
30002 492529			
	27.11.33.4	port-channel23.11	PUSH
30002 492529			
	37.1.53.4	Ethernet1/53/1	PUSH
29002 492529			
	37.1.54.4	Ethernet1/54/1	PUSH
29002 492529			
20002 402520	31.2.53.4	Ethernet1/53/2	PUSH
29002 492529			DUQU
	3/.2.34.4	Ethernet1/54/2	PUSH

29002 492529 80.211.11.1 Vlan801 PUSH 30002 492529

The following is an example of **show bgp l2vpn evpn summary** command.

show bgp 12vpn evpn summary BGP summary information for VRF default, address family L2VPN EVPN BGP router identifier 2.2.2.3, local AS number 2 BGP table version is 17370542, L2VPN EVPN config peers 4, capable peers 1 1428 network entries and 1428 paths using 268464 bytes of memory BGP attribute entries [476/76160], BGP AS path entries [1/6] BGP community entries [0/0], BGP clusterlist entries [0/0] 476 received paths for inbound soft reconfiguration 476 identical, 0 modified, 0 filtered received paths using 0 bytes V Neighbor AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd 1.1.1.1 4 11 0 0 0 0 0 23:01:53 Shut (Admin) 11 4 1836 17370542 1.1.1.9 4637 0 0 23:01:40 476 0 0 0 0 23:01:53 Shut (Admin) 1.1.1.10 4 11 0 1.1.1.11 4 11 0 0 0 0 0 23:01:52 Shut (Admin)

The following is an example of **show bgp l2vpn evpn** command.

1.1.1.9 (metric 0) from 1.1.1.9 (14.1.4.1)

```
show bgp 12vpn evpn 41.11.2.0
BGP routing table information for VRF default, address family L2VPN EVPN
Route Distinguisher: 14.1.4.1:115
BGP routing table entry for [5]:[0]:[24]:[41.11.2.0]:[0.0.0.0]/224, version 17369591
Paths: (1 available, best #1)
Flags: (0x000002) on xmit-list, is not in l2rib/evpn, is not in HW
  Advertised path-id 1
  Path type: external, path is valid, received and used, is best path
            Imported to 2 destination(s)
  AS-Path: 11 , path sourced external to AS
   1.1.1.9 (metric 0) from 1.1.1.9 (14.1.4.1)
     Origin incomplete, MED 0, localpref 100, weight 0
     Received label 492529
     Extcommunity: RT:2:20
  Path-id 1 not advertised to any peer
Route Distinguisher: 2.2.2.3:113
BGP routing table entry for [5]:[0]:[24]:[41.11.2.0]:[0.0.0.0]/224, version 17369595
Paths: (1 available, best #1)
Flags: (0x000002) on xmit-list, is not in l2rib/evpn, is not in HW
  Advertised path-id 1
  Path type: external, path is valid, is best path
             Imported from 14.1.4.1:115:[5]:[0]:[24]:[41.11.2.0]:[0.0.0.0]/224
  AS-Path: 11 , path sourced external to AS
```

Configuring Segment Routing with IS-IS Protocol

About IS-IS

IS-IS is an Interior Gateway Protocol (IGP) based on Standardization (ISO)/International Engineering Consortium (IEC) 10589 and RFC 1995. Cisco NX-OS supports Internet Protocol version 4 (IPv4) and IPv6. IS-IS is a dynamic link-state routing protocol that can detect changes in the network topology and calculate loop-free routes to other nodes in the network. Each router maintains a link-state database that describes the state of the network and sends packets on every configured link to discover neighbors. IS-IS floods the link-state information across the network to each neighbor. The router also sends advertisements and updates on the link-state database through all the existing neighbors

Segment routing on the IS-IS protocol supports the following:

- IPv4
- Level 1, level 2, and multi-level routing
- Prefix SIDs
- · Multiple IS-IS instances on the same loopback interface for domain border nodes
- · Adjacency SIDs for adjacencies

Configuring Segment Routing with IS-IS Protocol

You can configure segment routing with IS-IS protocol.

Before you begin

IS-IS segment routing is fully enabled when the following conditions are met:

- The mpls segment-routing feature is enabled.
- The IS-IS feature is enabled.
- Segment routing is enabled for at least one address family under IS-IS.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
Step 2	router isis instance-tag	Creates a new IS-IS instance with the configured instance tag.
Step 3	net network-entity-title	Configures the NET for this IS-IS instance.
Step 4	address-family <i>ipv4</i> unicast	Enters address family configuration mode.
Step 5	segment-routing mpls	Configures segment routing with IS-IS protocol.

Command or Action	Purpose
	 Note The IS-IS command is supported only on the IPv4 address family. It is not supported on the IPv6 address family. Redistribution is not supported from any other protocol to ISIS for the SR prefixes. You need to enable ip router isis command on all the prefix SID interfaces.

Configuring Segment Routing with OSPFv2 Protocol

About OSPF

Open Shortest Path First (OSPF) is an Interior Gateway Protocol (IGP) developed by the OSPF working group of the Internet Engineering Task Force (IETF). Designed expressly for IP networks, OSPF supports IP subnetting and tagging of externally derived routing information. OSPF also allows packet authentication and uses IP multicast when sending and receiving packets.

Segment routing configuration on the OSPF protocol can be applied at the process or the area level. If you configure segment routing at the process level, it is enabled for all the areas. However, you can enable ore disable it per area level.

Segment routing on the OSPF protocol supports the following:

- OSPFv2 control plane
- Multi-area
- IPv4 prefix SIDs for host prefixes on loopback interfaces
- · Adjacency SIDs for adjacencies

Adjacency SID Advertisement

OSPF supports the advertisement of segment routing adjacency SID. An Adjacency Segment Identifier (Adj-SID) represents a router adjacency in Segment Routing.

A segment routing-capable router may allocate an Adj-SID for each of its adjacencies and an Adj-SID sub-TLV is defined to carry this SID in the Extended Opaque Link LSA.

OSPF allocates the adjacency SID for each OSPF neighbor if the OSPF adjacency which are in two way or in FULL state. OSPF allocates the adjacency SID only if the segment routing is enabled. The label for adjacency SID is dynamically allocated by the system. This eliminates the chances of misconfiguration, as this has got only the local significance.

Connected Prefix-SID

OSPFv2 supports the advertisement of prefix SID for address associated with the loopback interfaces. In order to achieve this, OSPF uses Extended Prefix Sub TLV in its opaque Extended prefix LSA. When OSPF receives this LSA from its neighbor, SR label is added to the RIB corresponding to received prefix based upon the information present in extended prefix sub TLV.

For configuration, segment-routing has to be enabled under OSPF and corresponding to loopback interface that is configured with OSPF, prefix-sid mapping is required under the segment routing module.



SID will only be advertised for loopback addresses and only for intra-area and inter-area prefix types. No SID value will be advertised for external or NSSA prefixes.

Prefix Propagation Between Areas

To provide segment routing support across the area boundary, OSPF is required to propagate SID values between areas. When OSPF advertises the prefix reachability between areas, it checks if the SID has been advertised for the prefix. In a typical case, the SID value come from the router, which contributes to the best path to the prefix in the source area. In this case, OSPF uses such SID and advertises it between the areas. If the SID value is not advertised by the router which contributes to the best path inside the area, OSPF will use the SID value coming from any other router inside the source area.

Segment Routing Global Range Changes

OSPF advertises it's segment routing capability in terms of advertising the SID/Label Range TLV. In OSPFv2, SID/Label Range TLV is a carried in Router Information LSA.

The segment routing global range configuration will be under the "segment-routing mpls" configuration. When the OSPF process comes, it will get the global range values from segment-routing and subsequent changes should be propagated to it.

When OSPF segment routing is configured, OSPF must request an interaction with the segment routing module before OSPF segment routing operational state can be enabled. If the SRGB range is not created, OSPF will not be enabled. When an SRGB change event occurs, OSPF makes the corresponding changes in it's sub-block entries.

Conflict Handling of SID Entries

In an ideal situation, each prefix should have unique SID entries assigned.

When there is a conflict between the SID entries and the associated prefix entries use any of the following methods to resolve the conflict:

• Multiple SIDs for a single prefix - If the same prefix is advertised by multiple sources with different SIDs, OSPF will install the unlabeled path for the prefix. The OSPF takes into consideration only those SIDs that are from reachable routers and ignores those from unreachable routers. When multiple SIDs are advertised for a prefix, which is considered as a conflict, no SID will be advertised to the attached-areas for the prefix. Similar logic will be used when propagating the inter-area prefixes between the backbone and the non-backbone areas.

• Out of Range SID - For SIDs that do not fit in our SID range, labels are not used while updating the RIB.

MPLS Forwarding on an Interface

MPLS forwarding must be enabled before segment routing can use an interface. OSPF is responsible for enabling MPLS forwarding on an interface.

When segment routing is enabled for a OSPF topology, or OSPF segment routing operational state is enabled, it enables MPLS for any interface on which the OSPF topology is active. Similarly, when segment routing is disabled for a OSPF topology, it disables the MPLS forwarding on all interfaces for that topology.

MPLS forwarding is not supported on an interface which terminates at the IPIP/GRE tunnel.

Configuring Segment Routing with OSPFv2

Configure segment routing with OSPFv2 protocol.

Before you begin

Confirm that the following conditions are met before configuring segment routing with OSPFv2:

- The OSPFv2 feature is enabled.
- The segment-routing feature is enabled.
- Segment routing is enabled under OSPF.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[no]router ospf process	Enables the OSPF mode.
	Example:	
	<pre>switch(config)# router ospf test</pre>	
Step 3	segment-routing	Configures the segment routing functionality
	Example:	under OSPF.
	<pre>switch(config-router)# segment-routing mpls</pre>	

Configuring Segment Routing on OSPF Network- Area Level

Before you begin

Before you configure segment routing on OSPF network, OSPF must be enabled on your network.

Procedure

	Command or Action	Purpose
Step 1	router ospf process	Enables the OSPF mode.
	Example:	
	<pre>switch(config)# router ospf test</pre>	
Step 2	area <area id=""/> segment-routing [mpls disable]	Configures segment routing mpls mode in a specific area.
	Example:	
	<pre>switch(config-router)# area 1 segment-routing mpls</pre>	
Step 3	[no]area < <i>area id></i> segment-routing [mpls disable]	Disables segment routing mpls mode for the specified area.
	Example:	
	<pre>switch(config-router)#area 1 segment-routing disable</pre>	
Step 4	show ip ospf process segment-routing	Shows the output for configuring segment
	Example:	routing under OSPF.
	<pre>switch(config-router)# show ip ospf test segment-routing</pre>	

Configuring Prefix-SID for OSPF

This task explains how to configure prefix segment identifier (SID) index under each interface.

Before you begin

Segment routing must be enabled on the corresponding address family.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	switch# configure terminal	

	Command or Action	Purpose
Step 2	[no]router ospf process	Configures OSPF.
	Example:	
	<pre>switch(config)# router ospf test</pre>	
Step 3	segment-routing	Configures the segment routing functionality
	Example:	under OSPF.
	<pre>switch(config-router)# segment-routing switch(config-sr)#mpls switch(config-sr-mpls)#</pre>	
Step 4	interface loopback interface_number	Specifies the interface where OSPF is enabled.
	Example:	
	<pre>switch(config-sr-mpls)# Interface loopback 0</pre>	
Step 5	ip address 1.1.1.1/32	Specifies the IP address configured on the ospf
	Example:	interface.
	<pre>switch(config-sr-mpls)# ip address 1.1.1.1/32</pre>	
Step 6	ip router ospf 1 area 0	Specifies the OSPF enabled on the interface
	Example:	in area.
	<pre>switch(config-sr-mpls)# ip router ospf 1 area 0</pre>	
Step 7	segment-routing	Configures prefix-sid mapping under SR
	Example:	module.
	<pre>switch(config-router)#segment-routing (config-sr)#mpls</pre>	
Step 8	connected-prefix-sid-map	Configures the prefix SID mapping under the
	Example:	segment routing module.
	<pre>switch(config-sr-mpls)# connected-prefix-sid-map switch(config-sr-mpls-conn-pfxsid)#</pre>	
Step 9	address-family ipv4	Specifies the IPv4 address family configured
	Example:	on the OSPF interface.
	<pre>switch(config-sr-mpls-conn-pfxsid)# address-family ipv4 switch(config-sr-mpls-conn-pfxsid-af)#</pre>	
Step 10	1.1.1.1/32 index 10	Associates SID 10 with the address 1.1.1.1/32.
	Example:	
	<pre>switch(config-sr-mpls-conn-af)# 1.1.1.1/32 index 10</pre>	

	Command or Action	Purpose
Step 11	exit	Exits segment routing mode and returns to the
	Example:	configuration terminal mode.
	<pre>switch(config-sr-mpls-conn-af)# exit</pre>	

Configuring Prefix Attribute N-flag-clear

OSPF advertises prefix SIDs via Extended Prefix TLV in its opaque LSAs. It carries flags for the prefix and one of them is N flag (Node) indicating that any traffic sent along to the prefix is destined to the router originating the LSA. This flag typically marks host routes of router's loopback.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	interface loopback3	Specifies the interface loopback.
	Example:	
	<pre>switch(config)# interface loopback3</pre>	
Step 3	ip ospf prefix-attributes n-flag-clear	Clears the prefix N-flag.
	Example:	
	<pre>switch#(config-if)# ip ospf prefix-attributes n-flag-clear</pre>	

Configuration Examples for Prefix SID for OSPF

This example shows the configuration for prefix SID for OSPF.

```
Router ospf 10
Segment-routing mpls
Interface loop 0
Ip address 1.1.1.1/32
Ip router ospf 10 area 0
Segment-routing
Mpls
connected-prefix-sid-m
address-family ipv4
1.1.1.1/32 index 10
```

Configuring Segment Routing for Traffic Engineering

About Segment Routing for Traffic Engineering

Segment routing for traffic engineering (SR-TE) takes place through a tunnel between a source and destination pair. Segment routing for traffic engineering uses the concept of source routing, where the source calculates the path and encodes it in the packet header as a segment. A Traffic Engineered (TE) tunnel is a container of TE LSPs instantiated between the tunnel ingress and the tunnel destination. A TE tunnel can instantiate one or more SR-TE LSPs that are associated with the same tunnel.

With segment routing for traffic engineering (SR-TE), the network no longer needs to maintain a per-application and per-flow state. Instead, it simply obeys the forwarding instructions provided in the packet.

SR-TE utilizes network bandwidth more effectively than traditional MPLS-TE networks by using ECMP at every segment level. It uses a single intelligent source and relieves remaining routers from the task of calculating the required path through the network.

SR-TE Policies

Segment routing for traffic engineering (SR-TE) uses a "policy" to steer traffic through the network. A SR-TE policy is a container that includes sets of segments or labels. This list of segments can be provisioned by an operator, a stateful PCE. The head-end imposes the corresponding MPLS label stack on a traffic flow to be carried over the SR-TE policy. Each transit node along the SR-TE policy path uses the incoming top label to select the next-hop, pop or swap the label, and forward the packet to the next node with the remainder of the label stack, until the packet reaches the ultimate destination.

A SR-TE policy is uniquely identified by a tuple (color, end-point). A color is represented as a 32-bit number and an end-point is an IPv4. Every SR-TE policy has a color value. Every policy between the same node pairs requires a unique color value. Multiple SR-TE policies can be created between the same two endpoints by choosing different colors for the policies.

Cisco Nexus 9000 Series switches support the following two types of SR-TE policies:

- Dynamic SR-TE Policy When you configure dynamic path preference under the SR-TE policy configuration or an on-demand color configuration, the path computation engine (PCE) calculates the path to the destination address. Dynamic path calculation at PCE results in a list of segments/labels that gets applied to the head-end SR-TE policy, hence the traffic gets routed through the network by hitting the segments that the SR-TE policy holds.
- Explicit SR-TE Policy An explicit path is a list of labels, each representing a node or link in the explicit path. This feature is enabled through the **explicit-path** command that allows you to create an explicit path and enter a configuration submode for specifying the path.

SR-TE Policy Paths

A SR-TE policy path is a list of segments that specifies the path, called a segment ID (SID) list. Every SR-TE policy consists of one or more candidate paths, which can be either a dynamic or an explicit path. The SR-TE policy instantiates a single path and the selected path is the preferred valid candidate path.

You can also add on-demand color with dynamic path option and explicit policy configuration with an explicit path option for the same color and endpoint. In this case, a single policy is created on the head-end and the path with the highest preference number configured is used for forwarding traffic.

The following two methods are used to compute the SR-TE policy path:.

- Dynamic Path When you specify the dynamic PCEP option while configuring the path preference under an on-demand color configuration or a policy configuration, the path computation is delegated to a path computation engine(PCE).
- Explicit Path This path is an explicitly specified SID-list or a set of SID-lists.

Beginning with Cisco NX-OS Release 10.2(2)F, you can lockdown or shutdown an SR-TE policy or perform both; shutdown preference(s) of an SR-TE policy or an on-demand color template; force a specific preference to be active path option for SRTE policy; or force path re-optimization for all or a specific SRTE policy. This feature is supported on Cisco Nexus 9300-EX, 9300-FX, 9300-FX2, 9300-GX, and N9K-C9332D-GX2B platform switches. For more information, see Configuring SR-TE Manual Preference Selection, on page 36.

For more information about the Cisco Nexus 9000 switches that support various features spanning from release 7.0(3)I7(1) to the current release, refer to Nexus Switch Platform Support Matrix.

Affinity and Disjoint Constraints

Affinity Constraints - You can assign attributes to a link which gets advertised to path computation engine (PCE). SRTE process hosts the affinity-map and interface level configurations. Routing protocol(IGP) will register for interface updates and SRTE will notify IGP with interface updates. IGP the passed to BGP to advertise it to external peers. There are three types of affinity constraints:

- exclude-any: specifies that links that have any of the specified affinity colors must not be traversed by the path.
- include-any: specifies that only links that have any of the specified affinity colors must be traversed by the path. Thus, links that do not have any of the specified affinity colors must not be used.
- include-all: specifies that only links that have all of the specified affinity colors must be traversed by the path. Thus, links that do not have all of the specified affinity colors must not be used.

Disjoint Constraints - You can assign disjoint constraints to the SR-TE policies which gets advertised to the PCE. The PCE then provides the disjoint path for the policies that share the same association group ID and the disjoint disjointness type.

Cisco NX-OS Release 9.3(1) supports the following disjoint path levels :

- Link The paths transit different links (but may transit same nodes).
- Node disjointness The paths transit different links but may transit same node.

Segment Routing On Demand Next Hop

On-Demand Next hop (ODN) leverages upon BGP Dynamic SR-TE capabilities and adds the path computation (PCE) ability to find and download the end to end path based on the requirements. ODN triggers an SR-TE auto-tunnel based on the defined BGP policy. As shown in the following figure, an end-to-end path between ToR1 and AC1 can be established from both ends based on IGP Metric. The work-flow for ODN is summarized as follows:



Guidelines and Limitations for SR-TE

SR-TE has the following guidelines and limitations:

- SR-TE ODN for both, IPv4 and IPv6 overlay is supported.
- SR-TE ODN is supported only with IS-IS underlay.
- Forwarding does not support routes with recursive next hops, where the recursive next hop resolves to a route with a binding SID.
- Forwarding does not support mixing paths with binding labels and paths without binding labels for the same route.
- The affinity and disjoint constraints are applicable only to those SR-TE policies that have a dynamic PCEP option.
- XTC supports only two policies with disjointness in the same group.
- When configuring the SR-TE affinity interfaces, the interface range is not supported.
- A preference cannot have both, the dynamic PCEP and the explicit segment lists configured together for the same preference.
- Only one preference can have a dynamic PCEP option per policy.
- For explicit policy, when configuring ECMP paths under same preference, if the first hop (NHLFE) is same for both the ECMP paths, ULIB will only install one path in switching. This occurs because both the ECMP paths create the same SRTE FEC as the NHLFE is same for both.
- In Cisco NX-OS Release 9.3(1), unprotected mode with affinity configuration is not supported by PCE (XTC).

- Beginning with Cisco NX-OS Release 9.3(3), SR-TE ODN, policies, policy paths, and the affinity and disjoint constraints are supported on Cisco Nexus 9364C-GX, Cisco Nexus 9316D-GX, and Cisco Nexus 93600CD-GX switches.
- Beginning with Cisco NX-OS Release 10.2(2)F, few new show commands for SR-TE policy are introduced and the autocomplete feature is provided for some of the existing SR-TE policy commands to improve usability. This feature is supported on Cisco Nexus 9300-EX, 9300-FX, 9300-FX2, 9300-GX, and N9K-C9332D-GX2B platform switches.



For more information about the Cisco Nexus 9000 switches that support various features spanning release 7.0(3)I7(1) to the current release, refer to Nexus Switch Platform Support Matrix.

Configuring SR-TE

You can configure segment routing for traffic engineering.

Before you begin

You must ensure that the mpls segment routing feature is enabled.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
Step 2	segment-routing	Enters the segment-routing mode
Step 3	traffic-engineering	Enters the traffic engineering mode.
Step 4	encapsulation mpls source ipv4 tunnel_ip_address	Configures the source address for the SR-TE Tunnel.
Step 5	рсс	Enters the PCC mode.
Step 6	<pre>source-address ipv4 pcc_source_address</pre>	Configure source address for the PCC
Step 7	pce-address ipv4 pce_source_address precedence num	Configure IP address of the PCE. The lowest numbered PCE will take precedence, and the other(s) be used as a backup.
Step 8	on-demand color color_num	Enters the on-demand mode to configure the color.
Step 9	candidate-paths	Specifies the candidate paths of the policy.
Step 10	<pre>preference preference_number</pre>	Specifies the preference of the candidate path.
Step 11	dynamic	Specifies the path option.

I

	Command or Action	Purpose
Step 12	рсер	Specifies the path computation that needs to be done from the PCE.

Configuring Affinity Constraints

You can configure the affinity constraints to the SR-TE policy.

Before you begin

You must ensure that the mpls segment routing feature is enabled.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	<pre>Example: switch# configure terminal switch(config)#</pre>	
Step 2	<pre>segment-routing Example: switch(config)# segment-routing switch(config-sr)#</pre>	Enables the MPLS segment routing functionality.
Step 3	<pre>traffic-engineering Example: switch(config-sr)# traffic-engineering switch(config-sr-te)#</pre>	Enters the traffic engineering mode.
Step 4	рсс	Enters the PCC mode.
Step 5	source-address ipv4 pcc_source_address	Configure source address for the PCC
Step 6	pce-address ipv4 pce_source_address precedence num	Configure IP address of the PCE. The lowest numbered PCE takes precedence and the other(s) are used as a backup.
Step 7	<pre>affinity-map Example: switch(config-sr-te)#affinity-map switch(config-sr-te-affmap)#</pre>	Configures the affinity-map configuration mode.

	Command or Action	Purpose
Step 8	color name bit-position position	Configures a mapping of the user-defined name to a specific bit position in the affinity
	Example:	
	<pre>switch(config-sr-te-affmap)# color red bit-position 2 switch(config-sr-te-affmap)#</pre>	on-map.
Step 9	interface interface-name	Specifies the name of the interface. This is the
	Example:	affinity mapping name which refers to the specific bit in the affinity bitmap.
	<pre>Enter SRTE interface config mode switch(config-sr-te-if)#interface eth1/1 switch(config-sr-te-if)#</pre>	
Step 10	affinity	Adds the affinity color to the interface.
	Example:	
<pre></pre>	<pre>switch(config-sr-te-if)# affinity switch(config-sr-te-if-aff)# switch(config-sr-te-if-aff)# color red switch(config-sr-te-if-aff)#</pre>	
Step 11	policy name on-demand color color_num	Configures the policy.
	Example:	
	<pre>switch(config-sr-te)# on-demand color 211</pre>	
	or	
	<pre>switch(config-sr-te-color)# policy test_policy</pre>	
Step 12	color color end-point address	Configures the color and the end point of the policy. This is required when you are configuring the policy using the "policy name
	Example:	
switch(config-sr-te-pol)#color 200 endpoint 2.2.2.2	config mode.	
Step 13	candidate-path	Specifies the candidate paths for the policy.
	Example:	
	<pre>switch(config-sr-te-color)# candidate-paths switch(cfg-cndpath)#</pre>	
Step 14	preference preference_number	Specifies the preference of the candidate path.
	Example:	
	<pre>switch(cfg-cndpath)# preference 100 switch(cfg-pref)#</pre>	
Step 15	dynamic	Specifies the path option.
	Example:	
	<pre>switch(cfg-pref)# dynamic switch(cfg-dyn)#</pre>	

	Command or Action	Purpose
Step 16	<pre>pcep Example: switch(cfg-dyn)# pcep switch(cfg-dyn)#</pre>	Specifies that the headend uses PCEP to request the PCE to compute a path from itself to the segment routing's policy's end point.
Step 17	<pre>constraints Example: switch(cfg-dyn)# constraints switch(cfg-constraints)#</pre>	Enters the candidate path preference constraint mode.
Step 18	<pre>affinity Example: switch(cfg-constraints)# affinity switch(cfg-const-aff)#</pre>	Specifies the affinity constraints of the policy.
Step 19	<pre>exclude-any include-all include-any Example: switch(cfg-const-aff)# include-any switch(cfg-aff-inclany)#</pre>	 Specifies the affinity constraint type. The following affinity types are available: exclude-any - specifies that links that have any of the specified affinity colors must not be traversed by the path. include-any - specifies that only links that have any of the specified affinity colors must be traversed by the path. include-all - specifies that only links that have all of the specified affinity colors must be traversed by the path.
Step 20	<pre>color color_name Example: switch(cfg-aff-inclany)# color blue switch(cfg-aff-inclany)#</pre>	Specifies the affinity color definition.

Configuring Disjoint Paths

You can configure disjoint path constraints to the SR-TE policy.

Before you begin

You must ensure that the mpls segment routing feature is enabled.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	segment-routing	Enables the MPLS segment routing
	Example:	functionality.
	<pre>switch(config)# segment-routing switch(config-sr)#</pre>	
Step 3	traffic-engineering	Enters the traffic engineering mode.
	Example:	
	<pre>switch(config-sr)# traffic-engineering switch(config-sr-te)#</pre>	
Step 4	рсс	Enters the PCC mode.
Step 5	source-address ipv4 pcc_source_address	Configure source address for the PCC
Step 6	pce-address ipv4 pce_source_address	Configure IP address of the PCE.
	precedence num	The lowest numbered PCE takes precedence and the other(s) are used as a backup.
Step 7	policy name on-demand color color_num	Configures the policy.
	Example:	
	<pre>switch(config-sr-te)# on-demand color 211</pre>	
	or	
	<pre>switch(config-sr-te-color)# policy test_policy</pre>	
Step 8	color color end-point address	Configures the color and the end point of the
	Example:	configuring the policy using the "policy name"
	<pre>switch2(config-sr-te-pol)# color 200 endpoint 2.2.2.2</pre>	config mode.
Step 9	candidate-path	Specifies the candidate-paths for the policy
	Example:	
	<pre>switch(config-sr-te-color)# candidate-paths switch(cfg-cndpath)#</pre>	
Step 10	preference preference_number	Specifies the preference of the candidate path.
	Example:	

	Command or Action	Purpose
	<pre>switch(cfg-cndpath)# preference 100 switch(cfg-pref)#</pre>	
Step 11	dynamic	Specifies the path option.
	Example:	
	<pre>switch(cfg-pref)# dynamic switch(cfg-dyn)#</pre>	
Step 12	рсер	Specifies that the headend uses PCEP to
	Example:	to the segment routing's policy's end point.
	<pre>switch(cfg-dyn)# pcep switch(cfg-dyn)#</pre>	
Step 13	constraints	Enters the candidate path preference constraint
	Example:	mode.
	<pre>switch(cfg-dyn)# constraints switch(cfg-constraints)#</pre>	
Step 14	association-group	Specifies the association group type.
	Example:	
	<pre>switch(cfg-constraints)# association-group</pre>	
	switch (cfg-assoc) #	
Step 15	disjoint	Specifies the path that belongs to the
	Example:	disjointness association group.
	<pre>switch(cfg-assoc)# disjoint switch(cfg-disj)#</pre>	
Step 16	type link node	Specifies the disjointness group type.
	Example:	
	<pre>switch(config-if)#type link</pre>	
Step 17	id number	Specifies the identifier of the
	Example:	association-group.
	switch(config-if)#id 1	

Configuration Examples for SR-TE

The examples in this section show affinity and disjoint configurations.

This example shows the mappings of a user defined name to an administrative group.

```
segment-routing
traffic-eng
affinity-map
color green bit-position 0
color blue bit-position 2
color red bit-position 3
```

This example shows the affinity link colors red and green for the adjacency on eth1/1 and affinity link color green for the adjacency on eth1/2.

```
segment-routing
traffic-eng
interface eth1/1
affinity
color red
color green
!
interface eth1/2
affinity
color green
```

This examples shows the affinity constraints for the policy.

```
segment-routing
  traffic-engineering
   affinity-map
     color blue bit-position 0
     color red bit-position 1
   on-demand color 10
     candidate-paths
       preference 100
         dynamic
           pcep
          constraints
           affinity
              [include-any|include-all|exclude-any]
                color <col name>
                color <col_name>
   policy new policy
     color 201 endpoint 2.2.2.0
     candidate-paths
       preference 200
          dynamic
           pcep
          constraints
           affinity
              include-all
                color red
```

This examples shows the disjoint constraints for the policy.

```
segment-routing
traffic-eng
on-demand color 99
candidate-paths
preference 100
dynamic
pcep
constraints
association-group
disjoint
type link
id 1
```

Configuration Example for an SR-TE ODN - Use Case

Perform the following steps to configure ODN for SR-TE. The following figure is used as a reference to explain the configuration steps.

Figure 2: Reference Topology



- 1. Configure all links with IS-IS point-to-point session from PE1 to PE2. Also, configure the domains as per the above topology.
- 2. Enable "distribute link-state" for IS-IS session on R1, R3, and R6.

```
router isis 1
net 31.0000.0000.0000.712a.00
log-adjacency-changes
distribute link-state
address-family ipv4 unicast
bfd
segment-routing mpls
maximum-paths 32
advertise interface loopback0
```

3. Configure the router R1 (headend) and R6 (tailend) with a VRF interface.

VRF configuration on R1:

```
interface Ethernet1/49.101
encapsulation dot1q 201
  vrf member sr
  ip address 101.10.1.1/24
  no shutdown
vrf context sr
  rd auto
  address-family ipv4 unicast
   route-target import 101:101
    route-target import 101:101 evpn
   route-target export 101:101
   route-target export 101:101 evpn
router bgp 6500
  vrf sr
   bestpath as-path multipath-relax
   address-family ipv4 unicast
      advertise 12vpn evpn
```

4. Tags VRF prefix with BGP community on R6 (tailend).

```
route-map color1001 permit 10
set extcommunity color 1001
```

5. Enable BGP on R6 (tailend) and R1 (headend) to advertise and receive VRF SR prefix and match on community set on R6 (tailend).

R6 < EVPN > R3 < EVPN > R1

BGP Configuration R6:

```
router bgp 6500
address-family ipv4 unicast
allocate-label all
neighbor 53.3.3.3
remote-as 6500
log-neighbor-changes
update-source loopback0
address-family l2vpn evpn
send-community extended
route-map Color1001 out
encapsulation mpls
```

BGP Configuration R1:

```
router bgp 6500
address-family ipv4 unicast
allocate-label all
neighbor 53.3.3.3
remote-as 6500
log-neighbor-changes
update-source loopback0
address-family l2vpn evpn
send-community extended
encapsulation mpls
```

6. Enable BGP configuration on R3 and BGP LS with XTC on R1, R3.abd

BGP Configuration R3:

```
router bgp 6500
  router-id 2.20.1.2
address-family ipv4 unicast
allocate-label all
address-family 12vpn evpn
retain route-target all
 neighbor 56.6.6.6
    remote-as 6500
    log-neighbor-changes
   update-source loopback0
    address-family 12vpn evpn
      send-community extended
       route-reflector-client
       route-map NH UNCHANGED out
      encapsulation mpls
  neighbor 51.1.1.1
    remote-as 6500
    log-neighbor-changes
    update-source loopback0
    address-family 12vpn evpn
     send-community extended
      route-reflector-client
     route-map NH_UNCHANGED out
      encapsulation mpls
neighbor 58.8.8.8
    remote-as 6500
```

```
log-neighbor-changes
update-source loopback0
address-family link-state
route-map NH_UNCHANGED permit 10
set ip next-hop unchanged
```

BGP Configuration R1:

router bgp 6500 neighbor 58.8.8.8 remote-as 6500 log-neighbor-changes update-source loopback0 address-family link-state

BGP Configuration R6:

```
outer bgp 6500
neighbor 58.8.8.8
remote-as 6500
log-neighbor-changes
update-source loopback0
address-family link-state
```

7. Enable PCE and SR-TE tunnel configurations on R1.

```
segment-routing
traffic-engineering
pcc
source-address ipv4 51.1.1.1
pce-address ipv4 58.8.8.8
on-demand color 1001
metric-type igp
```

Configuring SR-TE Manual Preference Selection

This section describes the configuration and execution commands introduced to support manual preference selection feature.

Guidelines and Limitations for SR-TE Manual Preference Selection

The following guidelines and limitations apply to the SR-TE manual preference selection feature:

 Beginning with Cisco NX-OS Release 10.2(2)F, the SR-TE manual preference selection feature allows you to lockdown, shutdown, or perform both on an SRTE policy or an on-demand color template; shutdown preference(s) of an SR-TE policy or an on-demand color template. Furthermore, this feature also allows you to force a specific preference to be active for the SR-TE policy and force path re-optimization for all or a specific SR-TE policy.

This feature is supported on Cisco Nexus 9300-EX, 9300-FX, 9300-FX2, 9300-GX, and N9K-C9332D-GX2B platform switches.

About SR-TE Manual Preference – Lockdown and Shutdown

Beginning with Cisco NX-OS Release 10.2(2)F, you can perform the following actions as appropriate:
• Lockdown an SRTE policy – You can enable lockdown under on-demand color templates or explicit policies. Lockdown disables auto re-optimization of path preferences for a policy. In case a new higher preferred path comes up for a policy which is locked down, then it does not automatically switch to use the new path and continues to use the current active path option until it is valid.



Note If an explicit policy configuration exists for the same color as the on-demand template, then the policy configuration takes precedence over the template configuration for the lockdown.

Example

Consider a scenario where there are multiple preferences on a policy. Assume that the higher preference path goes down due to some fault in the network. The fault could be an impending failure of a node in the higher preference path. When investigating and rectifying the fault, the operations team may need to reload or disable the problematic node and prevent any disruptions while this occurs. Then, locking down the lower preference path and preventing switching back to the higher preference path is a good option to use.

Shutdown an SRTE policy – You can enable shutdown under on-demand color templates or explicit
policies. The policy state changes to admin down, and a policy down notification is sent to all the clients
interested in the policy. Disabling shutdown under on-demand color configuration changes the policy
state to up or down based on the path validity of the policy.



Note If an explicit policy configuration exists for the same color as the on-demand template, then the policy configuration takes precedence over the template configuration for the shutdown.

• Shutdown preference[s] of an SRTE policy – You can shut down a path preference under an on-demand color template configuration or under a path preference of explicit policy configuration. This disables that path preference and stops it from entering any future path re-optimization until the preference is unshut. The path preference is shown as admin down or up in the output of show srte policy based on whether it is shut or unshut in the configuration.

Configuring SR-TE Manual Preference – Lockdown/Shutdown

You can configure lockdown, shutdown, or both on an SR-TE policy or an on-demand color template. You can also shutdown a preference under an SR-TE policy or an on-demand color template.

Before you begin

You must ensure that the mpls segment routing feature is enabled.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.

	Command or Action	Purpose
Step 2	segment-routing	Enters the segment-routing mode.
Step 3	traffic-engineering	Enters the traffic engineering mode.
Step 4	on-demand colorcolor_num or policy name	Enters the on-demand mode to configure the color or configures the SR-TE policy respectively.
Step 5	(optional) [no] lockdown	Enables lockdown under the on-demand color template or explicit policy configuration. Note When an explicit policy configuration exists for the same color as the on-demand template, then the policy configuration takes precedence over the template configuration, and the policy is locked down.
Step 6	(optional) [no] shutdown	Shuts down any policy created from the on-demand color template or the configured SR-TE policy, as appropriate. Note When an explicit policy configuration exists for the same color as the on- demand template, then the policy configuration takes precedence over the template configuration, and the policy is shut down.
Step 7	candidate-paths	Specifies the candidate paths of the policy.
Step 8	preference preference_number	Specifies the preference of the candidate path.
Step 9	(optional) [no] shutdown	Shuts down a path preference under an SR-TE policy configuration or an on-demand color template configuration.

Force a Specific Path Preference for an SRTE Policy

To force a specific preference to be the active path option for an SRTE policy, use the segment-routing traffic-engineering switch name <policy_name> pref <preference_number> execution command. This command uses the preference until it is valid.

A sample output is as follows:

```
NX2# show srte policy Green_White
Policy: 8.8.8.0|801
Name: Green_White
Source: 2.2.2.0
End-point: 8.8.8.0
```

```
State: UP
Color: 801
Authorized: Y
Binding-sid Label: 22
Policy-Id: 3
Path type = MPLS Active path option
Path-option Preference:180 ECMP path count: 1
1. PCE Weighted: No
Delegated PCE: 11.11.11.11
Index: 1 Label: 16005
Index: 2 Label: 16008
NX2# segment-routing traffic-engineering switch name Green White preference 170
NX2(cfg-pref) # show srte policy Green white detail
Policy: 8.8.8.0|801
Name: Green White
.....
Path type = MPLS Path options count: 4
Path-option Preference:180 ECMP path count: 1 Admin: UP Forced: No
1. PCE Weighted: No
Delegated PCE: 11.11.11.11
Index: 1 Label: 16005
Index: 2 Label: 16008
Path-option Preference: 170 ECMP path count: 1 Admin: UP Forced: Yes Active path option
1. Explicit Weighted: No
Name: Yellow
Index: 1 Label: 16006
Index: 2 Label: 16008
```

To undo this manually selected preference, you can perform any one of the following options:

- Use the segment-routing traffic-engineering reoptimize name <policy_name> command. For more information, see the Force path re-optimization for an SRTE Policy or All SRTE Policies, on page 39 section.
- Switch to another preference
- Shut this policy
- Shut the selected preference

Force path re-optimization for an SRTE Policy or All SRTE Policies

When there are multiple preferences for an SRTE policy, you can re-optimize a policy, that is, pick the best preferred available path.

To force path re-optimization for a specific SRTE policy, use the segment-routing traffic-engineering reoptimize name <policy_name> command. The <policy_name> can be the name or alias name of the policy. This command undoes the preference switch command explained in the previous section and overrides lockdown if configured.

A sample output is as follows:

```
NX2# show srte policy Green_White
Policy: 8.8.8.0|801
Name: Green_White
Source: 2.2.2.0
End-point: 8.8.8.0
State: UP
Color: 801
Authorized: Y
Binding-sid Label: 22
```

```
Policy-Id: 3
Path type = MPLS Active path option
Path-option Preference:170 ECMP path count: 1
1. Explicit Weighted: Yes Weight: 1
Name: Yellow
Index: 1 Label: 16006
Index: 2 Label: 16008
NX2# segment-routing traffic-engineering reoptimize name Green White
NX2# show srte policy Green White
Policy: 8.8.8.0|801
Name: Green White
Source: 2.2.2.0
End-point: 8.8.8.0
State: UP
Color: 801
Authorized: Y
Binding-sid Label: 22
Policy-Id: 3
Path type = MPLS Active path option
Path-option Preference: 180 ECMP path count: 1
1. PCE Weighted: No
Delegated PCE: 11.11.11.11
Index: 1 Label: 16005
Index: 2 Label: 16008
```

To force path re-optimization for all SRTE policies, use the segment-routing traffic-engineering reoptimize all command to force path re-optimization for all SRTE policies present on the system. This command undoes the preference switch command explained in the previous point and overrides lockdown if configured.

Configuring SRTE Flow-based Traffic Steering

This chapter describes how to configure SRTE flow-based traffic steering on Cisco Nexus 9000-FX, 9000-FX2, 9000-FX3, 9000-GX, and 9300 platform switches.

About SRTE Flow-based Traffic Steering

The Flow-based Traffic Steering feature for Cisco NX-OS release 10.1(2) provides an alternate method of choosing the traffic to be steered, which is direct and flexible. This method allows configuring the source routing on the headend node directly, rather than on the egress node. Flow-based traffic steering allows the user to select which packets will be steered into an SRTE policy by matching fields in the incoming packet such as destination address, UDP or TCP port, DSCP bits and other properties. The matching is done by programming an ACL to steer packets into the policy.

To match and steer traffic, the Policy-Based Routing (PBR) feature is enhanced to support SRTE policies. The current PBR feature involves the RPM, ACL Manager, and AclQoS components. Beginning from Cisco NX-OS release 10.1(2), to add SRTE support, the RPM component also communicates with the SRTE and ULIB, and the communication with URIB is enhanced.

Thus, the flow-based traffic steering feature for SRTE includes the following:

- MPLS SR dataplane
- Steering IPv4 traffic is supported in default VRF, and steering IPv4 as well as IPv6 traffic is supported in non-default VRF

- Matching traffic by ACL based on a combination of the 5 tuple fields (source addr, destination addr, protocol, tcp/udp source port, tcp/udp destination port)
- · Steering matched traffic into an SRTE policy
- Matching on the DSCP/TOS bits in the packet for IPv4 packets
- Matching on the Traffic Class field of the packet for IPv6 packets
- · Automatic enabling and disabling of ACLs based on time-period definitions
- · When steering VRF cases, support steering into an SRTE policy without specifying a next hop
- · Overlay ECMP using anycast endpoints
- · Packets matched by ACL take precedence over regular routes
- · Flow selection based on ToS/DSCP and timer-based ACL
- The next-hop-ip is used in steering traffic to SRTE policy from one endpoint to another

Guidelines and Limitations for Flow-based Traffic Steering for SRTE

The following guidelines and limitations apply to the Flow-based Traffic Steering for SRTE feature:

- Beginning with Cisco NX-OS release 10.1(2), the flow-based traffic steering features for SRTE are supported on the Cisco Nexus 9000-FX, 9000-FX2, 9000-FX3, 9000-GX, and 9300 platform switches.
- When the SRTE policy is applied to a route-map assigned to an interface in a VRF (to steer L3VPN/L3EVPN traffic), if the next hop in the set statement resolves to a BGP prefix, and that BGP prefix is already using an SRTE policy to steer traffic, then the route-map does not steer traffic.
- Underlay ECMP is only supported if label stack is the same for each active SRTE path (ECMP member) in the policy. The 9000-GX platforms do not have this limitation.
- The route-map tracking feature is not supported.
- When steering into SRTE policies, having multiple **set next-hop** in a single route-map sequence entry is not supported.
- When the SRTE policy is applied to a route-map assigned to an interface in a VRF (to steer L3VPN/L3EVPN traffic), if the next hop in the set statement resolves to a BGP route (overlay route) that has multiple next hops in RIB, the traffic is only steered to the first next hop in the route and will not ECMP over all next hops.
- When the SRTE policy name is used in the route-map set statement, rather than color and endpoint, it can only be used for default VRF steering. If not, you must select an SRTE path that is defined explicitly. Specifically, this cannot be used to select SRTE policies defined to use a segment-list containing the policy-endpoint keyword in place of a label.
- The following keywords, which are applicable for the next hop-ip specified in the **set ip next-hop** <>, are not supported in the route-map when steering into SRTE policies:
 - · verify-availability
 - drop-on-fail
 - force-order

• load-share

- Route-map with srte-policy can be applied on the interface even if the required features (segmenting-routing, 13 evpn or 13vpn) are not enabled on the device. But the set-actions with srte-policy are kept down, that is, default-routing will be done for those flows.
- · A route-map can have set commands with srte-policy and without srte-policy.
- For set-commands without srte-policy information, steering is done only if the reachability to the next-hop-ip does not require MPLS label.
- When a route-map is associated with an interface in a non-default VRF, and that route-map contains a sequence that specifies a next hop IP address **N** and an SRTE policy, then all other sequences on that route-map and all other route-maps associated with the same VRF that also use the same next hop IP address must also have an SRTE policy. Associating another route-map or route-map sequence using the same next hop IP and a different SRTE policy to the same VRF is not allowed.
- Similarly, when a route-map is associated with an interface in a non-default VRF, and that route-map does not specify an SRTE policy but specifies a next hop IP address **N**, then another sequence in that route-map or a separate route-map is not applied that uses the same next hop IP address N and specifies an SRTE policy.
- The SRTE flow-based traffic steering cannot be used at the same time as VXLAN or EoMPLS PBR.
- The SR label stats are not supported for policy based routed traffic on the SRTE ingress node. However, ACL redirect stats are supported.
- The IPv6 traffic in the default VRF cannot be steered into an SRTE policy. The MPLS SR underlay is only supported for IPv4. However, if an IPv6 SR underlay is required, use SRv6 instead.
- The 9000-FX, 9000-FX2, 9000-FX3, and 9300 platform hardware are unable to push unique underlay label stack per ECMP member, which impacts underlay ECMP on those platforms. In other words, if there are multiple active segment-lists on an SRTE policy (a single preference is configured with multiple segment-lists) where the first hop of the segment lists is different, then such a configuration is not supported. In such cases, as a workaround, configure anycast SID to make the label stack same across all ECMP members.
- Modular platforms are not supported in Cisco NX-OS release 10.1(2).
- Beginning with Cisco NX-OS release 10.2(2)F, the flow-based traffic steering features for SRTE are supported on the Cisco N9K-C9332D-GX2B platform switches.

Configuration Process: SRTE Flow-based Traffic Steering

The configuration process for the SRTE Flow-based Traffic Steering feature is as follows:

1. Configure the IP access lists, especially matching the criteria on the IP access list.

For more information, see the *Configuring IP ACLs* chapter in the *Cisco Nexus Series NX-OS Security Configuration Guide*.

2. Define the SRTE policy.

For more information about configuring SRTE, see the *Configuring Segment Routing for Traffic Engineering* chapter in the *Cisco Nexus 9000 series NX-OS Label Switching Configuration Guide*.

3. Configure the route map that binds the match (IP access list configured in step 1) and action. The match refers to the fields to match on the packet, and the action refers to what SRTE policy to steer into and the VPN label to use, if any.

Configuring Flow Selection Based on ToS/DSCP and Timer-based ACL

In the SRTE flow-based traffic steering feature, the flow selection is based on ToS/DSCP and Timer based ACL.

Perform the following configuration procedure for the route map configuration in default and non-default VRF into a policy selected by different criteria to work properly.

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[ip ipv6] access-list acl_name	Use a name to define an IP or IPv6 access list
	Example:	and enter the IP or IPv6 access-list
	<pre>switch(config)# ip access-list L4_PORT switch(config)#</pre>	configuration mode.
Step 3	10 permit ip <i>ip_address</i> any	Shows the IP or IPv6 access lists configured
	Example:	on the switch.
	<pre>switch(config)# 10 permit ip any 5.5.0.0/16 switch(config)#</pre>	
Step 4	20 permit tcp tcp_address [any]	Sets TCP permit conditions for an IP or IPv6
	Example:	access list.
	<pre>switch(config)# 20 permit tcp any 5.5.0.0/16 switch(config)#</pre>	Note The any keyword is used for IPv6 only.
Step 5	[ip ipv6] access-list dscp_name	Use a name to define DSCP for an IP or IPv6
	Example:	access list and enter the IP or IPv6 access-list
	<pre>switch(config)# ip access-list dscp switch(config)#</pre>	
Step 6	10 permit tcp any tcp_address dscp <dscp value></dscp 	Set the DSCP value for an IP or IPv6 access list.
	Example:	Note

	Command or Action	Purpose
	<pre>switch(config)# 10 permit tcp any 5.5.0.0/16 dscp af11 switch(config)#</pre>	The any keyword is used for IPv6 only.
Step 7	<pre>[ip ipv6] access-list acl_name Example: switch(config)# ip access-list acll switch(config)#</pre>	Use a name to define an IP or IPv6 access list and enter the IP or IPv6 access-list configuration mode.
Step 8	10 permit tcp any tcp_address acl acl_name Example: switch(config)# 10 permit tcp any 5.5.0.0/16 eq www dscp af11 switch(config)#	Sets TCP permit conditions for an IP or IPv6 access list. Note The any keyword is used for IPv6 only.
Step 9	<pre>[ip ipv6] access-list acl_name Example: switch(config) # ip access-list acl1 switch(config) #</pre>	Use a name to define an IP or IPv6 access list and enter the IP or IPv6 access-list configuration mode.
Step 10	10 permit tcp any any time - range tl Example: switch(config-acl)# 10 permit tcp any 5.5.0.0/16 eq www dscp af11 switch(config)#	Sets time range value to define the time range for TCP for an IP or IPv6 access list. Note The any keyword is used for IPv6 only.
Step 11	<pre>time-range name Example: switch(config-acl)# time-range t1 switch(config)#</pre>	Use a name to define the time range for an IP or IPv6 access list.
Step 12	F2(config-time-range)# WOLF2(config-time-range)# Example: switch(config-time-range)# 10 absolute start 20:06:56 8 february 2021 end 20:10:56 8 february 2021	Define a time range for the configuration.

Configuring Route Map in Default and Non-default VRF for Flow-based Traffic Steering

The following sections show how to configure the route map in default and non-default VRF for the SRTE flow-based traffic steering feature:

Configuring Route Map in Default VRF into a Policy Selected by Color and Endpoint

Perform the following steps to configure a route-map that steers traffic in the default VRF into a policy that is selected by color and endpoint.

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

Procedure

	Command or Action	Purpose
Step 1	route-map FLOW1 seq_num	Names the route map FLOW1.
	Example:	
	<pre>switch(config)# route-map FLOW1 seq 10 switch(config-route-map)#</pre>	
Step 2	match [ip ipv6] address acl_name	Specifies the fields the route-map should match
	Example:	by attaching an ACL describing the fields.
	<pre>switch(config-route-map)# match ip address L4_PORT switch(config-route-map)#</pre>	
Step 3	set srte-policy color num endpoint ip address	Configures the SRTE policy color and the end
	Example:	point of the policy.
	<pre>switch(config-route-map)# set srte-policy color 121 endpoint 10.0.0.1 switch(config-route-map)#</pre>	, Note Only IPv4 address can be the endpoint.
Step 4	interface interface-type/slot/port	Enters interface configuration mode.
	Example:	
	<pre>switch(config-route-map)# interface ethernet 1/1 switch(config-route-map-if)#</pre>	
Step 5	[ip ipv6] policy route-map FLOW1	Assigns a route map for IP or IPv6 policy-based
	Example:	routing to the interface. This applies the
	<pre>switch(config-route-map-if)# ip policy route-map FLOW1 switch(config-route-map-if)#</pre>	interface.

Configuring Route Map in Default VRF into a Policy Selected by Name

Perform the following steps to configure a route-map that steers traffic in the default VRF into a policy that is selected by name.

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

Procedure

	Command or Action	Purpose
Step 1	route-map FLOW1 seq_num	Names the route map FLOW1.
	Example:	
	<pre>switch(config)# route-map FLOW1 seq 10 switch(config-route-map)#</pre>	
Step 2	match [ip ipv6] address acl_name	Specifies the fields the route-map should match
	Example:	by attaching an ACL describing the fields.
	<pre>switch(config-route-map)# match ip address L4_PORT switch(config-route-map)#</pre>	
Step 3	set srte-policy name policy-name	Configures the SRTE policy name.
	Example:	
	<pre>switch(config-route-map)# set srte-policy name policy1 switch(config-route-map)#</pre>	
Step 4	interface interface-type/slot/port	Enters the interface configuration mode.
	Example:	
	<pre>switch(config-route-map)# interface ethernet 1/1 switch(config-route-map-if)#</pre>	
Step 5	[ip ipv6] policy route-map FLOW1	Assigns a route map for IP or IPv6 policy-based
	Example:	routing to the interface. This applies the
	<pre>switch(config-route-map-if)# ip policy route-map FLOW1 switch(config-route-map-if)#</pre>	interface.

Configuring Route Map in Non-default VRF into a Policy Selected by Nexthop, Color, and Endpoint

Perform the following steps to configure a route-map that steers traffic in a non-default VRF into a policy that is selected by color and endpoint. In this procedure, a nexthop is specified so that the correct MPLS VPN label is imposed on the traffic.

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

	Command or Action	Purpose
Step 1	route-map FLOW1 seq_num	Names the route map FLOW1.
	Example:	

	Command or Action	Purpose
	<pre>switch(config)# route-map FLOW1 seq 10 switch(config-route-map)#</pre>	
Step 2	match [ip ipv6] address acl_name	Specifies the fields the route-map should match by attaching an ACL describing the fields.
	<pre>Example: switch(config-route-map)# match ip address L4_PORT switch(config-route-map)#</pre>	
Step 3	set [ip ipv6] next-hop destination-ip-next-hop srte-policy color num endpoint ip address	Redirects packet to the configured next-hop through the srte-policy (color and endpoint).
	<pre>Example: switch(config-route-map)# set ip next-hop 5.5.5.5 srte-policy color 121 endpoint 10.0.0.1 switch(config-route-map)#</pre>	
Step 4	<pre>exit Example: switch(config-route-map)# exit switch(config)#</pre>	Exits the route-map configuration mode and returns to the global configuration mode.
Step 5	<pre>interface interface-type/slot/port Example: switch(config)# interface ethernet 1/1 switch(config-if)#</pre>	Enters the interface configuration mode.
Step 6	<pre>vrf member vrf-name Example: switch(config-if)# vrf member vrf1 switch(config-if)#</pre>	Adds this interface to a VRF.
Step 7	<pre>[ip ipv6] policy route-map FLOW1 Example: switch(config-if) # ip policy route-map FLOW1 switch(config-if) #</pre>	Assigns a route map for IP or IPv6 policy-based routing to the interface. This applies the route-map for all the traffic ingressing into the interface.
Step 8	<pre>[no] shutdown Example: switch(config-if) # no shutdown switch(config-if) #</pre>	Disables the interface.

Configuring Route Map in Non-default VRF into a Policy Selected by Nexthop and Color

Perform the following steps to configure a route-map that steers traffic in the default VRF into a policy that is selected by color and endpoint, but the endpoint is not explicitly configured. The nexthop is specified so that the correct MPLS VPN label is imposed on the traffic and so the correct SRTE endpoint is derived from the route matching the nexthop.

I

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

Procedure

	Command or Action	Purpose
Step 1	route-map FLOW1 seq_num	Names the route map FLOW1.
	Example:	
_	<pre>switch(config)# route-map FLOW1 seq 10 switch(config-route-map)#</pre>	
Step 2	match [ip ipv6] address acl_name	Specifies the fields the route-map should match
	Example:	by attaching an ACL describing the fields.
	switch(config-route-map)# match ip address L4 FORT	
	switch(config-route-map)#	
Step 3	set [ip ipv6] next-hop destination-ip-next-hop srte-policy color num	Redirects packet to the configured next-hop through the srte-policy (color).
	Example:	
	<pre>switch(config-route-map)# set ip next-hop 5.5.5.5 srte-policy color 121 switch(config-route-map)#</pre>	
Step 4	exit	Exits the route-map configuration mode and
	Example:	returns to the global configuration mode.
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	interface interface-type/slot/port	Enters the interface configuration mode.
	Example:	
	<pre>switch(config)# interface ethernet 1/1 switch(config-if)#</pre>	
Step 6	vrf member vrf-name	Adds this interface to a VRF.
	Example:	
	<pre>switch(config-if)# vrf member vrf1 switch(config-if)#</pre>	
Step 7	[ip ipv6] policy route-map FLOW1	Assigns a route map for IP or IPv6 policy-based
	Example:	routing to the interface. This applies the route-map for all the traffic ingressing into the
	switch(config-if)# ip policy route-map	interface.
	switch(config-if-route-map)#	
Step 8	[no] shutdown	Disables the interface.
	Example:	

Command or Action	Purpose
<pre>switch(config-if-route-map)# no shutdown switch(config-if-route-map)#</pre>	

Configuring Route Map in Non-default VRF into a Policy Selected by Nexthop and Name

Perform the following steps to configure a route-map that steers traffic in a non-default VRF into a policy that is selected by name. The nexthop is specified so that the correct MPLS VPN label is imposed on the traffic

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

	Command or Action	Purpose
Step 1	route-map FLOW1 seq_num	Names the route map FLOW1.
	Example:	
	<pre>switch(config)# route-map FLOW1 seq 10 switch(config-route-map)#</pre>	
Step 2	match [ip ipv6] address acl_name	Specifies the fields the route-map should match
	Example:	by attaching an ACL describing the fields.
	<pre>switch(config-route-map)# match ip</pre>	
	switch (config-route-map) #	
Step 3	set [ip ipv6] next-hop destination-ip-next-hop srte-policy name	Redirects packet to the configured next-hop through the srte-policy (name).
	Example:	
	<pre>switch(config-route-map)# set ip next-hop 5.5.5.5 srte-policy policy1 switch(config-route-map)#</pre>	
Step 4 exit Exits	Exits the route-map configuration mode and	
	Example:	returns to the global configuration mode.
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	interface interface-type/slot/port	Enters the interface configuration mode.
	Example:	
	<pre>switch(config)# interface ethernet 1/1 switch(config-if)#</pre>	
Step 6	vrf member vrf-name	Adds this interface to a VRF.
	Example:	
	<pre>switch(config-if)# vrf member vrf1 switch(config-if)#</pre>	

	Command or Action	Purpose
Step 7	[ip ipv6] policy route-map FLOW1	Assigns a route map for IP or IPv6 policy-based routing to the interface. This applies the route-map for all the traffic ingressing into the interface.
	Example:	
	<pre>switch(config-if)# ip policy route-map FLOW1 switch(config-if)#</pre>	
Step 8	[no] shutdown	Disables the interface.
	Example:	
	<pre>switch(config-if)# no shutdown switch(config-if)#</pre>	

Configuring Route Map in Non-default VRF into a Policy Selected by Color and Endpoint

Perform the following steps to configure a route-map that steers traffic in a non-default VRF into a policy that is selected by color and endpoint. This procedure does not require a nexthop to be specified. The VPN label is derived by looking up the label assigned to the VRF on the local switch. This is only allowed to be configured when the same label is assigned to the VRF on all switches by using the BGP allocate-index configuration for the VRF on all switches.

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

	Command or Action	Purpose
Step 1	route-map FLOW1 seq_num	Names the route map FLOW1.
	Example:	
	<pre>switch(config)# route-map FLOW1 seq 10 switch(config-route-map)#</pre>	
Step 2	match [ip ipv6] address acl_name	Specifies the fields the route-map should match by attaching an ACL describing the fields.
	Example:	
	<pre>switch(config-route-map)# match ip address L4_PORT switch(config-route-map)#</pre>	
Step 3	set srte-policy color num endpoint ip address	Configures the SRTE policy color and the end point of the policy.
	Example:	
	<pre>switch(config-route-map)# set srte-policy color 121 endpoint 10.0.0.1 switch(config-route-map)#</pre>	Note Only IPv4 address can be the endpoint.
Step 4	interface interface-type/slot/port	Enters the interface configuration mode.
	Example:	
	<pre>switch(config-route-map)# interface ethernet 1/1 switch(config-route-map-if)#</pre>	

	Command or Action	Purpose
Step 5	vrf member vrf-name	Adds this interface to a VRF.
	Example:	
	<pre>switch(config-route-map-if)# vrf member vrf1</pre>	
	<pre>switch(config-route-map-if)#</pre>	
Step 6	[ip ipv6] policy route-map FLOW1	Assigns a route map for IP or IPv6
	Example:	policy-based routing to the interface. This applies the route-map for all the traffic
	<pre>switch(config-route-map-if)# ip policy route-map FLOW1</pre>	ingressing into the interface.
	<pre>switch(config-route-map-if)#</pre>	
Step 7	[no] shutdown	Disables the interface.
	Example:	
	<pre>switch(config-route-map-if)# no shutdown switch(config-route-map-if)#</pre>	
Step 8	exit	Exits the route-map configuration mode and
	Example:	returns to the global configuration mode.
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 9	feature bgp	Enters the BGP feature.
	Example:	
	<pre>switch(config)# feature bgp switch(config)#</pre>	
Step 10	router bgp as-number	Configures a BGP routing process and enters
	Example:	router configuration mode.
	<pre>switch(config)# router bgp 1.1 switch(config-router)#</pre>	
Step 11	vrf vrf-name	Associates the BGP process with a VRF.
	Example:	
	<pre>switch(config-router)# vrf vrf1 switch(config-router-vrf)#</pre>	
Step 12	allocate-index index	Assigns an index to the VRF. This instructs
	Example:	BGP to allocate a static MPLS local VPN label for the VRF. The MPLS VPN label assigned
	<pre>switch(config-router-vrf)# allocate-index 10</pre>	to the VRF is derived from the value specified - the index is used as an offset into a special range of MPLS label values. For a given index value the same local label is always allocated.

Configuring Route Map in Non-default VRF into a Policy Selected by Name

Perform the following steps to configure a route-map that steers traffic in a non-default VRF into a policy that is selected by name. This procedure does not require a nexthop to be specified. The VPN label is derived by looking up the label assigned to the VRF on the local switch. This is only allowed to be configured when the same label is assigned to the VRF on all switches by using the BGP allocate-index configuration for the VRF on all switches.

Before you begin

You must ensure that the MPLS segment routing traffic engineering and PBR features are enabled.

	Command or Action	Purpose
Step 1	route-map FLOW1 seq_num	Names the route map FLOW1.
	Example:	
	<pre>switch(config)# route-map FLOW1 seq 10 switch(config-route-map)#</pre>	
Step 2	match [ip ipv6] address acl_name	Specifies the fields the route-map should match
	Example:	by attaching an ACL describing the fields.
	<pre>switch(config-route-map)# match ip address L4_PORT switch(config-route-map)#</pre>	
Step 3	set srte-policy name	Configures the SRTE policy name.
	Example:	
	<pre>switch(config-route-map)# set srte-policy policy1 switch(config-route-map)#</pre>	
Step 4	interface interface-type/slot/port	Enters interface configuration mode.
	Example:	
	<pre>switch(config-route-map)# interface ethernet 1/1 switch(config-route-map-if)#</pre>	
Step 5	vrf member vrf-name	Adds this interface to a VRF.
	Example:	
	<pre>switch(config-route-map-if)# vrf member vrf1 switch(config-route-map-if)#</pre>	
Step 6	[ip ipv6] policy route-map FLOW1	Assigns a route map for IP or IPv6
	Example:	policy-based routing to the interface. This
	<pre>switch(config-route-map-if)# ip policy route-map FLOW1 switch(config-route-map-if)#</pre>	ingressing into the interface.

	Command or Action	Purpose
Step 7	[no] shutdown	Disables the interface.
	Example:	
	<pre>switch(config-route-map-if)# no shutdown switch(config-route-map-if)#</pre>	
Step 8	exit	Exits the route-map configuration mode and returns to the global configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 9	feature bgp	Enters the BGP feature.
	Example:	
	<pre>switch(config)# feature bgp switch(config)#</pre>	
Step 10	router bgp as-number	Configures a BGP routing process and enters
	Example:	router configuration mode.
	<pre>switch(config)# router bgp 1.1 switch(config-router)#</pre>	
Step 11	vrf vrf-name	Associates the BGP process with a VRF.
	Example:	
	<pre>switch(config-router)# vrf vrf1 switch(config-router-vrf)#</pre>	
Step 12	allocate-index index	Assigns an index to the VRF. This instructs
	Example:	BGP to allocate a static MPLS local VPN label
	<pre>switch(config-router-vrf)# allocate-index 10</pre>	to the VRF is derived from the value specified - the index is used as an offset into a special range of MPLS label values. For a given index value the same local label is always allocated.

Configuration Example for SRTE Flow-based Traffic Steering

This section includes the following examples for configuring flow-based traffic steering for SRTE:

Configuration Example for Flow Selection Based on ToS/DSCP and Timer-based ACL

```
switch# configure terminal
switch(config)# ip access-list L4_PORT
switch(config)# 10 permit ip any 5.5.0.0/16
switch(config)# 20 permit tcp any 5.5.0.0/16
switch(config)# ip access-list dscp
switch(config)# 10 permit tcp any 5.5.0.0/16 dscp af11
switch(config)# ip access-list acl1
switch(config)# 10 permit tcp any 5.5.0.0/16 eq www dscp af11
switch(config)# ip access-list acl1
switch(config)# ip access-list acl1
switch(config)# 10 permit tcp any 5.5.0.0/16 eq www dscp af11
```

```
switch(config-acl)# time-range t1
start 20:06:56 8 february 2021 end 20:10:56 8 february 2021
```

Configuration Example for Route Map in Default VRF into a Policy Selected by Color and Endpoint

```
switch(config)# route-map FLOW1 seq 10
switch(config-route-map)# match ip address L4_PORT
switch(config-route-map)# set srte-policy color 121 endpoint 10.0.0.1
switch(config-route-map)# interface ethernet 1/1
switch(config-route-map-if)# ip policy route-map FLOW1
```

Configuration Example for Route Map in Default VRF into a Policy Selected by Name

```
switch(config)# route-map FLOW1 seq 10
switch(config-route-map)# match ip address L4_PORT
switch(config-route-map)# set srte-policy name policy1
switch(config-route-map)# interface ethernet 1/1
switch(config-route-map-if)# ip policy route-map FLOW1
```

Configuration Example for Route Map in Non-default VRF into a Policy Selected by Next hop, Color, and Endpoint

```
switch(config) # route-map FLOW1 seq 10
switch(config-route-map) # match ip address L4_PORT
switch(config-route-map) # set ip next-hop 5.5.5.5 srte-policy color 121 endpoint 10.0.0.1
switch(config-route-map) # interface ethernet 1/1
switch(config-route-map) # vrf member vrf1
switch(config-route-map-if) # ip policy route-map FLOW1
```

Configuration Example for Route Map in Non-default VRF into a Policy Selected by Next hop and Color

```
switch(config)# route-map FLOW1 seq 10
switch(config-route-map)# match ip address L4_PORT
switch(config-route-map)# set ip next-hop 5.5.5.5 srte-policy color 121
switch(config-route-map)# interface ethernet 1/1
switch(config-route-map)# vrf member vrf1
switch(config-route-map-if)# ip policy route-map FLOW1
```

Configuration Example for Route Map in Non-default VRF into a Policy Selected by Next hop and Name

```
switch(config)# route-map FLOW1 seq 10
switch(config-route-map)# match ip address L4_PORT
switch(config-route-map)# set ip next-hop 5.5.5.5 srte-policy policy1
switch(config-route-map)# interface ethernet 1/1
switch(config-route-map)# vrf member vrf1
switch(config-route-map-if)# ip policy route-map FLOW1
```

Configuration Example for Route Map in Non-default VRF into a Policy Selected by Color and Endpoint

```
switch(config) # route-map FLOW1 seq 10
switch(config-route-map) # match ip address L4_PORT
switch(config-route-map) # set srte-policy color 121 endpoint 10.0.0.1
switch(config-route-map) # interface ethernet 1/1
switch(config-route-map) # vrf member vrf1
switch(config-route-map-if) # ip policy route-map FLOW1
```

L

```
switch(config)# feature bgp
switch(config)# router bgp 1.1
switch(config-router)# vrf vrf1
switch(config-router-vrf)# allocate-index 10
```

Configuration Example for Route Map in Non-default VRF into a Policy Selected by Name

```
switch(config)# route-map FLOW1 seq 10
switch(config-route-map)# match ip address L4_PORT
switch(config-route-map)# set srte-policy policy1
switch(config-route-map)# interface ethernet 1/1
switch(config-route-map-if)# ip policy route-map FLOW1
switch(config)# feature bgp
switch(config)# router bgp 1.1
switch(config-router)# vrf vrf1
switch(config-router-vrf)# allocate-index 10
```

Verifying Configuration for Flow-based Traffic Steering for SRTE

To display the appropriate details about the flow-based steering for SRTE configuration, perform one of the following tasks:

Command	Purpose
show srte policy	Displays only the authorized policies.
show srte policy [all]	Displays the list of all policies available in the SR-TE.
show srte policy [detail]	Displays the detailed view of all the requested policies.
<pre>show srte policy <name></name></pre>	Filters the SR-TE policy with the name and displays the list of all policies available with that name in the SR-TE.
	Note This command has the autocomplete feature for the policy-name. To use this feature, add a question mark or press TAB.
<pre>show srte policy color <color> endpoint <endpoint></endpoint></color></pre>	Displays the SR-TE policy for the color and endpoint. Note This command has the autocomplete feature for color and endpoint. To use this feature, add a question mark or press TAB.
show route-map [name]	Displays information about a route map.
show forwarding mpls srte module	Displays SRTE information in Forwarding Information Base - FIB module.

Table 1: Verifying Configuration for Flow-based Traffic Steering for SRTE

Configuring MPLS OAM Monitoring for SRTE Policies

About MPLS OAM Monitoring for SRTE Policies

Beginning with Cisco NX-OS release 10.1(2), MPLS OAM monitoring allows the switch on which one or more SRTE policies are configured to proactively detect if the active path or paths of an SRTE policy have failed. If the paths in the currently active preference have all failed, SRTE will consider that preference down and so make the next highest preference on the policy active, if there is such a preference, or otherwise mark the policy as down.

Before this feature, the state of an SRTE preference and policy was only determined by the state of the first hop (the first MPLS label) of the paths in the preference. If the label was programmed the path was considered up, and if the label was missing or invalid the path was considered down.

The MPLS OAM monitoring augments this validation by sending MPLS LSPV Nil-FEC ping requests continuously along the SRTE path. Each ping request contains the same label stack as would be imposed on traffic that follows the SRTE policy, making the pings take the same path. The pings are sent with a configurable interval between each ping, and a response to the ping from the final node of the path is expected within the interval. If a failure response is returned from the final node or no response is received within the interval, it is counted as a failed interval. After a configurable number of failed intervals occur in sequence, the path is considered down. If all paths in a preference are down, then the preference is considered down.

Paths Monitored

Only when the CLIs are enabled to monitor a path using proactive monitoring will the path be monitored using OAM. Only the paths that are associated with a policy will be monitored. For example, if a segment list is created and is not associated with a policy it is not monitored. As well, if the same path is used in multiple policies only one monitoring session will be created for that path. This applies whether the path is a segment-list associated to a preference in a policy or is calculated using path completion on the headend.

By default, when the image is upgraded from a version without OAM monitoring support to a version with monitoring support, the monitoring method for policies will be the traditional first-hop method.

MPLS OAM monitoring may be enabled globally for all SRTE policies. If enabled globally, it can be selectively disabled per policy. If not enabled globally, it can be enabled selectively for individual policies.

Index Limit

The index-limit X CLI is used to ping only an initial subset of the path rather than the entire path. Only indexes in the segment list that are less than or equal to the specified index-limit are part of the path to monitor. For example, if the segment list is the following:

index 100 mpls label 16001
index 200 mpls label 16002
index 300 mpls label 16003

Then if index-limit is not specified, the path to be pinged will be 16001, 16002, 16003. If index-limit is 250, then the path to be pinged will be 16001, 16002. If index-limit is 200, then the path to be pinged will also be 16001, 16002.

Guidelines and Limitations for MPLS OAM Monitoring for SRTE Policies

The MPLS OAM monitoring for SRTE policies has the following guidelines and limitations:

- Beginning with Cisco NX-OS Release 10.1(2), MPLS OAM monitoring (continuous and proactive path) is introduced and supported on Cisco Nexus 9300 EX, 9300-FX, 9300-FX2, and 9300-GX platform switches.
- On the head-end node where the SRTE policies are configured, both SRTE and MPLS OAM must be separately enabled as part of feature mpls segment-routing traffic-engineering and feature mpls oam respectively. If not, the user cannot configure the monitoring of SRTE policies using OAM. In addition, the remaining nodes in the SR fabric must have MPLS OAM enabled using feature mpls oam to respond to the pings sent by MPLS OAM monitoring.
- SRTE limits the maximum number of monitoring sessions to 1000.
- The minimum interval between pings is 1000 milliseconds.
- When SRTE OAM monitoring policies are running on a device, feature mpls oam cannot be disabled. Only when all the SRTE OAM monitoring policies are disabled, the feature mpls oam can be disabled from the device. Otherwise, the following error message is displayed:

"SRTE MPLS liveness detection is either enabled for all policies, is enabled for at least one policy, or is enabled for an on-demand color. Please ensure liveness detection is completely disabled before disabling MPLS OAM."

- In Cisco NX-OS Release 10.1(2) SRTE OAM monitoring is supported for static policies and on-demand color having explicit path configured.
- The OAM sessions do not run for paths that are configured with dynamic option using PCEP.

Configuring MPLS OAM Monitoring

This section describes the CLIs required to enable proactive path monitoring for policies.

Global Configuration

This configuration enables OAM path monitoring for all configured policies.

• Policy-specific Configuration

This configuration enables OAM path monitoring for a specific policy.

Global Configuration

Before you begin

You must ensure that the MPLS segment routing traffic engineering feature is enabled.

I

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	segment-routing	Enters the segment routing configuration
	Example:	mode.
	<pre>switch (config) #segment-routing switch (config-sr) #</pre>	
Step 3	traffic-engineering	Enters the traffic engineering mode.
	Example:	
	<pre>switch(config-sr)# traffic-engineering switch(config-sr-te)#</pre>	
Step 4	[liveness-detection]	Enters the liveness-detection configuration
	Example:	mode.
	<pre>switch(config-sr-te)# liveness-detection switch(config-sr-te-livedet)#</pre>	
Step 5	interval num	The duration of the interval in milliseconds.
	Example:	The default is 3000 ms.
	<pre>switch(config-sr-te-livedet)# interval 6000 switch(config-sr-te-livedet)#</pre>	
Step 6	multiplier num	The multiplier sets the number of consecutive
	Example:	intervals that must fail for a path that is up to
	<pre>switch(config-sr-te-livedet) # multiplier</pre>	consecutive intervals for a path that is down
	switch(config-sr-te-livedet)#	to be considered up. The default is 3.
Step 7	mpls	Enables segment routing over mpls.
	Example:	
	<pre>switch(config-sr-te-livedet)# mpls switch(config-sr-te-livedet-mpls)#</pre>	
Step 8	[no]oam	Enable MPLS OAM Monitoring globally for
	Example:	all SRIE policies.
	<pre>switch(config-sr-te-livedet-mpls)# oam switch(config-sr-te-livedet-mpls)#</pre>	The no form of this command disables OAM monitoring.
Step 9	segment-list name sidlist-name	Creates the explicit SID list.
	Example:	Note

	Command or Action	Purpose
	<pre>switch(config-sr-te)# segment-list name blue index 10 mpls label 16004 index 10 mpls label 16005</pre>	This command has the autocomplete feature for the sidlist-name. To use this feature, add a question mark or press TAB.
Step 10	policy policy name	Configures the policy.
	<pre>Example: switch(config-sr-te)# policy 1 switch(config-sr-te-pol)</pre>	
Step 11	color numberIP-end-point	Configures the color and the endpoint of the
	Example:	policy.
	<pre>switch(config-sr-te-pol)# color 1 endpoint 5.5.5.5 switch(config-sr-te-pol)</pre>	
Step 12	candidate-paths	Specifies the candidate paths for the policy.
	<pre>Example: switch(config-sr-te-pol)# candidate-paths switch(config-expcndpaths)#</pre>	
Step 13	preference preference-number	Specifies the preference of the candidate path.
	<pre>Example: switch(config-expcndpaths)# preference 100 switch(cfg-pref)#</pre>	
Step 14	explicit segment-list sidlist-name	Specifies the explicit list.
	<pre>Example: switch(cfg-pref)# explicit segment-list red switch(cfg-pref)#</pre>	Note This command has the autocomplete feature for the sidlist-name. To use this feature, add a question mark or press TAB.
Step 15	on-demand color color_num	Enters the on-demand color template mode to
	Example:	configure an on-demand color for the specified color.
	<pre>switch(config-sr-te)# on-demand color 211 switch(config-sr-te-color)#</pre>	
Step 16	candidate-paths	Specifies the candidate paths for the policy.
	Example:	
	<pre>switch(config-sr-te-color)# candidate-paths switch(cfg-cndpath)#</pre>	
Step 17	preference preference-number	Specifies the preference of the candidate path.
	Example:	

I

	Command or Action	Purpose
	<pre>switch(cfg-cndpath)# preference 100 switch(cfg-pref)#</pre>	
Step 18	explicit segment-list sidlist-name	Specifies the explicit list.
	<pre>Example: switch(cfg-pref)# explicit segment-list red switch(cfg-pref)#</pre>	Note This command has the autocomplete feature for the sidlist-name. To use this feature, add a question mark or press TAB.

Policy-specific Configuration

Before you begin

You must ensure that the MPLS segment routing traffic engineering feature is enabled.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	segment-routing	Enters the segment routing configuration mode.
	Example:	
	<pre>switch(config)#segment-routing switch(config-sr)#</pre>	
Step 3	traffic-engineering	Enters the traffic engineering mode.
	Example:	
	<pre>switch(config-sr)# traffic-engineering switch(config-sr-te)#</pre>	
Step 4	[liveness-detection]	Enters the liveness-detection configuration mode.
	Example:	
	<pre>switch(config-sr-te)# liveness-detection switch(config-sr-te-livedet)#</pre>	
Step 5	interval num	The duration of the interval in milliseconds.
	Example:	The default is 3000 ms.
	<pre>switch(config-sr-te-livedet)# interval</pre>	
	switch(config-sr-te-livedet)#	
Step 6	multiplier num	The multiplier sets the number of consecutive
	Example:	intervals that must fail for a path that is up to be considered down and the number of

	Command or Action	Purpose
	<pre>switch(config-sr-te-livedet)# multiplier 5 switch(config-sr-te-livedet)#</pre>	consecutive intervals for a path that is down to be considered up. The default is 3.
Step 7	segment-list name sidlist-name	Creates the explicit SID list.
	<pre>Example: switch(config-sr-te)# segment-list name blue index 10 mpls label 16004 index 10 mpls label 16005</pre>	Note This command has the autocomplete feature for the sidlist-name. To use this feature, add a question mark or press TAB.
Step 8	policy policy name	Configures the policy.
	<pre>Example: switch(config-sr-te)# policy 1 switch(config-sr-te-pol)</pre>	
Step 9	<pre>color numberIP-end-point Example: switch(config-sr-te-pol)# color 1 endpoint 5.5.5.5 switch(config-sr-te-pol)</pre>	Configures the color and the endpoint of the policy.
Step 10	candidate-paths	Specifies the candidate paths for the policy.
	<pre>Example: switch(config-sr-te-pol)# candidate-paths switch(config-expcndpaths)#</pre>	
Step 11	preference preference-number	Specifies the preference of the candidate path.
	<pre>Example: switch(config-expcndpaths)# preference 100 switch(cfg-pref)#</pre>	
Step 12	explicit segment-list sidlist-name	Specifies the explicit list.
	<pre>Example: switch(cfg-pref)# explicit segment-list red switch(cfg-pref)#</pre>	Note This command has the autocomplete feature for the sidlist-name. To use this feature, add a question mark or press TAB.
Step 13	<pre>[liveness-detection] Example: switch(config-sr-te)# liveness-detection switch(config-sr-te-livedet)#</pre>	Enters the liveness-detection configuration mode.
Step 14	[no]index-limit <i>num</i> Example:	Monitors only SIDs that have an index of less than or equal to the user-specified number.

	Command or Action	Purpose
	<pre>switch(config-sr-te-livedet)# index-limit 20 switch(config-sr-te-livedet)#</pre>	
Step 15	[no]shutdown	Disables liveness detection. This is useful to
	Example:	temporarily disable liveness detection without entirely removing all related configuration.
	<pre>switch(config-sr-te-livedet) # shutdown switch(config-sr-te-livedet) #</pre>	The no form of this command disables OAM monitoring.
Step 16	mpls	Enables segment routing over mpls.
	Example:	
	<pre>switch(config-sr-te-livedet) # mpls switch(config-sr-te-livedet-mpls) #</pre>	
Step 17	[no]oam	Enable MPLS OAM Monitoring globally for
	Example:	all SRTE policies.
	<pre>switch(config-sr-te-livedet-mpls)# oam switch(config-sr-te-livedet-mpls)#</pre>	The no form of this command disables OAM monitoring.
Step 18	on-demand color color_num	Enters the on-demand color template mode to
	Example:	configure an on-demand color for the specified color.
	<pre>switch(config-sr-te)# on-demand color 211 switch(config-sr-te-color)#</pre>	
Step 19	candidate-paths	Specifies the candidate paths for the policy.
	Example:	
	<pre>switch(config-sr-te-color)# candidate-paths switch(cfg-cndpath)#</pre>	
Step 20	preference preference-number	Specifies the preference of the candidate path.
	Example:	
	<pre>switch(cfg-cndpath)# preference 100 switch(cfg-pref)#</pre>	
Step 21	explicit segment-list sidlist-name	Specifies the explicit list.
	Example:	Note
	<pre>switch(cfg-pref)# explicit segment-list red switch(cfg-pref)#</pre>	This command has the autocomplete feature for the sidlist-name. To use this feature, add a question mark or press TAB.
Step 22	[liveness-detection]	Enters the liveness-detection configuration
	Example:	mode.
	<pre>switch(config-sr-te-color)# liveness-detection switch(config-sr-te-color-livedet)#</pre>	

	Command or Action	Purpose
Step 23	[no]index-limit num	Monitors only SIDs that have an index of less
	Example:	than or equal to the user-specified number.
	<pre>switch(config-sr-te-color-livedet)# index-limit 20 switch(config-sr-te-color-livedet)#</pre>	
Step 24	[no]shutdown	Disables liveness detection. This is useful to
	Example:	temporarily disable liveness detection without entirely removing all related configuration
	<pre>switch(config-sr-te-color-livedet)# shutdown switch(config-sr-te-color-livedet)#</pre>	The no form of this command disables OAM monitoring.
Step 25	mpls	Enables segment routing over mpls.
	<pre>Example: switch(config-sr-te-color-livedet)# mpls switch(config-sr-te-color-livedet-mpls)#</pre>	
Step 26	[no]oam	Enable MPLS OAM Monitoring globally for
	<pre>Example: switch(config-sr-te-color-livedet-mpls)# oam switch(config-sr-te-color-livedet-mpls)#</pre>	all SRTE policies. The no form of this command disables OAM monitoring.

Verifying Configuration for MPLS OAM Monitoring

To display MPLS OAM monitoring configuration information, perform one of the following tasks:

Table 2: Verifying Configuration for MPLS OAM Monitoring

Command	Purpose
show srte policy	Displays only the authorized policies.
show srte policy [all]	Displays the list of all policies available in the SR-TE.
show srte policy [detail]	Displays the detailed view of all the requested policies.
<pre>show srte policy <name></name></pre>	Filters the SR-TE policy with the name and displays the list of all policies available with that name in the SR-TE.
	Note This command has the autocomplete feature for the policy-name. To use this feature, add a question mark or press TAB.

Command	Purpose
<pre>show srte policy color <color> endpoint <endpoint></endpoint></color></pre>	Displays the SR-TE policy for the color and endpoint. Note This command has the autocomplete feature for color and endpoint. To use this feature, add a question mark or press TAB.
show srte policy proactive-policy-monitoring	 Displays the list of all active proactive policy monitoring sessions that exist in the promon database. Note You can use the question mark option at the end of this command and provide one of the following options or press ENTER to display all the sessions: brief - shows brief information about the sessions color - shows the promon sessions related to the policy color name - shows the promon sessions related to the policy name session-id - shows the promon session for the session-id
show srte policy proactive-policy-monitoring [brief]	Displays only the list of session IDs and the states of the proactive policy monitoring sessions.
<pre>show srte policy proactive-policy-monitoring [session <session-id>]</session-id></pre>	Filters using session-id and displays information about that session in detail. Note This command has the autocomplete feature for the session-id. To use this feature, add a question mark or press TAB.
<pre>show srte policy proactive-policy-monitoring color <color> endpoint<endpoint></endpoint></color></pre>	Filters using color and endpoint and displays proactive policy monitoring sessions. Note This command has the autocomplete feature for color and endpoint. To use this feature, add a question mark or press TAB.

Configuration Example for MPLS OAM Monitoring

The following example shows how to configure MPLS OAM monitoring:

• Configuration example for global enablement with user specified multiplier and interval:

```
segment-routing
  traffic-engineering
    liveness-detection
        interval 6000
        multiplier 5
      mpls
        oam
    segment-list name blue
      index 10 mpls label 16004
      index 20 mpls label 16005
    segment-list name green
      index 10 mpls label 16003
      index 20 mpls label 16006
    segment-list name red
      index 10 mpls label 16002
      index 20 mpls label 16004
      index 30 mpls label 16005
    policy customer-1
      color 1 endpoint 5.5.5.5
      candidate-paths
        preference 100
          explicit segment-list red
    on-demand color 211
      candidate-paths
        preference 100
          explicit segment-list green
```

 Configuration example for policy enablement with user specified multiplier, interval, index-limit and shutdown option:

```
segment-routing
  traffic-engineering
    liveness-detection
       interval 6000
        multiplier 5
    segment-list name blue
      index 10 mpls label 16004
      index 20 mpls label 16005
    segment-list name green
      index 10 mpls label 16003
      index 20 mpls label 16006
    segment-list name red
      index 10 mpls label 16002
      index 20 mpls label 16004
      index 30 mpls label 16005
    policy customer-1
      color 1 endpoint 5.5.5.5
      candidate-paths
        preference 100
         explicit segment-list red
      liveness-detection
        index-limit 20
        shutdown
        mpls
          oam
    on-demand color 211
      candidate-paths
        preference 100
          explicit segment-list green
      liveness-detection
          index-limit 20
          shutdown
          mpls
            oam
```

Configuring Egress Peer Engineering with Segment Routing

BGP Prefix SID

In order to support segment routing, BGP requires the ability to advertise a segment identifier (SID) for a BGP prefix. A BGP prefix SID is always global within the segment routing BGP domain and identifies an instruction to forward the packet over the ECMP-aware best path computed by BGP to the related prefix. The BGP prefix SID identifies the BGP prefix segment.

Adjacency SID

The adjacency segment Identifier (SID) is a local label that points to a specific interface and a next hop out of that interface. No specific configuration is required to enable adjacency SIDs. Once segment routing is enabled over BGP for an address family, for any interface that BGP runs over, the address family automatically allocates an adjacency SID toward every neighbor out of that interface.

High Availability for Segment Routing

In-service software upgrades (ISSUs) are minimally supported with BGP graceful restart. All states (including the segment routing state) must be relearned from the BGP router's peers. During the graceful restart period, the previously learned route and label state are retained.

Overview of BGP Egress Peer Engineering With Segment Routing

Cisco Nexus 9000 Series switches are often deployed in massive scale data centers (MSDCs). In such environments, there is a requirement to support BGP Egress Peer Engineering (EPE) with Segment Routing (SR).

Segment Routing (SR) leverages source routing. A node steers a packet through a controlled set of instructions, known as segments, by prepending the packet with an SR header. A segment can represent any topological or service-based instruction. SR allows steering a flow through any topological path or any service chain while maintaining per-flow state only at the ingress node of the SR domain. For this feature, the Segment Routing architecture is applied directly to the MPLS data plane.

In order to support Segment Routing, BGP requires the ability to advertise a Segment Identifier (SID) for a BGP prefix. A BGP prefix is always global within the SR or BGP domain and it identifies an instruction to forward the packet over the ECMP-aware best-path that is computed by BGP to the related prefix. The BGP prefix is the identifier of the BGP prefix segment.

The SR-based Egress Peer Engineering (EPE) solution allows a centralized (SDN) controller to program any egress peer policy at ingress border routers or at hosts within the domain.

In the following example, all three routers run iBGP and they advertise NRLI to one another. The routers also advertise their loopback as the next-hop and it is recursively resolved. This provides an ECMP between the routers as displayed in the illustration.



Figure 3: Example of Egress Peer Engineering

The SDN controller receives the Segment IDs from the egress router 1.1.1.1 for each of its peers and adjacencies. It can then intelligently advertise the exit points to the other routers and the hosts within the controller's routing domain. As displayed in the illustration, the BGP Network Layer Reachability Information (NLRI) contains both the Node-SID to Router 1.1.1.1 and the Peer-Adjacency-SID 24003 indicating that the traffic to 7.7.7.7 should egress over the link 12.1.1.1->12.1.1.3.

Guidelines and Limitations for BGP Egress Peer Engineering

BGP Egress Peer Engineering has the following guidelines and limitations:

- BGP Egress Peer Engineering is only supported for IPv4 BGP peers. IPv6 BGP peers are not supported.
- BGP Egress Peer Engineering is only supported in the default VPN Routing and Forwarding (VRF) instance.
- Any number of Egress Peer Engineering (EPE) peers may be added to an EPE peer set. However, the installed resilient per-CE FEC is limited to 32 peers.
- A given BGP neighbor can only be a member of a single peer-set. Peer-sets are configured. Multiple peer-sets are not supported. An optional **peer-set** name may be specified to add neighbor to a peer-set. The corresponding RPC FEC load-balances the traffic across all the peers in the peer-set. The peer-set name is a string that is a maximum length of 63 characters (64 NULL terminated). This length is consistent with the NX-OS policy name lengths. A peer can only be a member of a single peer-set.
- Adjacencies for a given peer are not separately assignable to different peer-sets.
- Beginning with Cisco NX-OS Release 9.3(3), BGP Egress Peer Engineering is supported on Cisco Nexus 9300-GX platform switches.

Configuring Neighbor Egress Peer Engineering Using BGP

With the introduction of RFC 7752 and draft-ietf-idr-bgpls-segment-routing-epe, you can configure Egress Engineering. The feature is valid only for external BGP neighbors and it is not configured by default. Egress Engineering uses RFC 7752 encoding.

Before you begin

- · You must enable BGP.
- After an upgrade from Release 7.0(3)I3(1) or Release 7.0(3)I4(1), configure the TCAM region before configuring Egress Peer Engineering (EPE) on Cisco Nexus 9000 Series switches using the following commands:
- 1. switch# hardware access-list tcam region vpc-convergence 0
- 2. switch# hardware access-list tcam region racl 0
- 3. switch# hardware access-list tcam region mpls 256 double-wide
- Save the configuration and reload the switch.

For more information, see the Using Templates to Configure ACL TCAM Region Sizes and Configuring ACL TCAM Region Sizes sections in the *Cisco Nexus 9000 Series NX-OS Security Configuration Guide*.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	<pre>router bgp <bgp autonomous="" number=""></bgp></pre>	Specifies the autonomous router BGP number.
Step 3	neighbor <ip address=""></ip>	Configures the IP address for the neighbor.
Step 4	<pre>[no default] egress-engineering [peer-set peer-set-name] Example: switch(config) # router bgp 1 switch(config-router) # neighbor 4.4.4.4 switch(config-router) # egress-engineering peer-set NewPeer</pre>	Specifies whether a Peer-Node-SID is allocated for the neighbor and it is advertised in an instance of a BGP Link-State (BGP-LS) address family Link NLRI. If the neighbor is a multi-hop neighbor, a BGP-LS Link NLRI instance is also advertised for each Equal-Cost-MultiPath (ECMP) path to the neighbor and it includes a unique Peer-Adj-SID. Optionally, you can add the neighbor to a peer-set. The Peer-Set-SID is also advertised in the BGP-LS Link NLRI in the same instance as the Peer-Node-SID. BGP Link-State NLRI is advertised to all neighbors with the link-state address family configured. See RFC 7752 and draft-ietf-idr-bgpls-segment-routing-epe-05 for more information on EPE.

Configuration Example for Egress Peer Engineering

See the Egress Peer Engineering sample configuration for the BGP speaker 1.1.1.1. Note that the neighbor 20.20.20 is the SDN controller.

```
hostname epe-as-1
install feature-set mpls
feature-set mpls
feature telnet
feature bash-shell
feature bgp
feature mpls segment-routing
segment-routing mpls
vlan 1
vrf context management
    ip route 0.0.0.0/0 10.30.97.1
    ip route 0.0.0.0/0 10.30.108.1
```

```
interface Ethernet1/1
  no switchport
  ip address 10.1.1.1/24
  no shutdown
interface Ethernet1/2
  no switchport
  ip address 11.1.1.1/24
  no shutdown
interface Ethernet1/3
  no switchport
  ip address 12.1.1.1/24
  no shutdown
interface Ethernet1/4
  no switchport
  ip address 13.1.1.1/24
  no shutdown
interface Ethernet1/5
  no switchport
  ip address 14.1.1.1/24
  no shutdown
interface mgmt0
  ip address dhcp
  vrf member management
interface loopback1
  ip address 1.1.1.1/32
line console
line vty
ip route 2.2.2.2/32 10.1.1.2
ip route 3.3.3/32 11.1.1.3
ip route 3.3.3.3/32 12.1.1.3
ip route 4.4.4.4/32
                     13.1.1.4
ip route 20.20.20.20/32 14.1.1.20
router bgp 1
  address-family ipv4 unicast
  address-family link-state
 neighbor 10.1.1.2
    remote-as 2
    address-family ipv4
    egress-engineering
 neighbor 3.3.3.3
   remote-as 3
   address-family ipv4
   update-source loopback1
   ebgp-multihop 2
   egress-engineering
 neighbor 4.4.4.4
   remote-as 4
   address-family ipv4
   update-source loopback1
   ebgp-multihop 2
   egress-engineering
neighbor 20.20.20.20
   remote-as 1
   address-family link-state
   update-source loopback1
```

```
ebgp-multihop 2
neighbor 124.11.50.5
bfs
remote-as 6
update-source port-channel50.11
egress-engineering peer-set pset2 <<<<<
address-family ipv4 unicast
neighbor 124.11.101.2
bfd
remote-as 6
update-source Vlan2401
egress-engineering
address-family ipv4 unicast
```

This example shows sample output for the **show bgp internal epe** command.

```
switch# show bgp internal epe
BGP Egress Peer Engineering (EPE) Information:
Link-State Server: Inactive
Link-State Client: Active
Configured EPE Peers: 26
Active EPE Peers: 3
EPE SID State:
RPC SID Peer or Set Assigned
ID Type Set Name ID Label Adj-Info, iod
1 Node 124.1.50.5 1 1600
2 Set pset1 2 1601
3 Node 6.6.6.6 3 1602
4 Node 124.11.50.5 4 1603
5 Set pset2 5 1604
6 Adj 6.6.6.6 6 1605 124.11.50.4->124.11.50.5/0x1600b031, 80
7 Adj 6.6.6.6 7 1606 124.1.50.4->124.1.50.5/0x16000031, 78
EPE Peer-Sets:
IPv4 Peer-Set: pset1, RPC-Set 2, Count 7, SID 1601
Peers: 124.11.116.2 124.11.111.2 124.11.106.2 124.11.101.2
124.11.49.5 124.1.50.5 124.1.49.5
IPv4 Peer-Set: pset2, RPC-Set 5, Count 5, SID 1604
Peers: 124.11.117.2 124.11.112.2 124.11.107.2 124.11.102.2
124.11.50.5
IPv4 Peer-Set: pset3, RPC-Set 0, Count 4, SID unspecified
Peers: 124.11.118.2 124.11.113.2 124.11.108.2 124.11.103.2
IPv4 Peer-Set: pset4, RPC-Set 0, Count 4, SID unspecified
Peers: 124.11.119.2 124.11.114.2 124.11.109.2 124.11.104.2
IPv4 Peer-Set: pset5, RPC-Set 0, Count 4, SID unspecified
Peers: 124.11.120.2 124.11.115.2 124.11.110.2 124.11.105.2
switch#
```

Configuring the BGP Link State Address Family

You can configure the BGP link state address family for a neighbor session with a controller to advertise the corresponding SIDs. You can configure this feature in global configuration mode and neighbor address family configuration mode.

Before you begin

You must enable BGP.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	<pre>router bgp <bgp autonomous="" number=""></bgp></pre>	Specifies the autonomous router BGP number.
Step 3	[no] address-family link-state	Enters address-family interface configuration
	Example:	mode.
	<pre>switch(config)# router bgp 64497 switch(config-router af)# address-family link-state</pre>	Note This command can also be configured in neighbor address-family configuration mode.
Step 4	neighbor <ip address=""></ip>	Configures the IP address for the neighbor.
Step 5	[no] address-family link-state	Enters address-family interface configuration
	Example:	mode.
	<pre>switch(config)#router bgp 1 switch(config-router)#address-family link-state switch(config-router)#neighbor 20.20.20.20 switch(config-router)#address-family link-state</pre>	Note This command can also be configured in neighbor address-family configuration mode.

BGP Prefix SID Deployment Example

In the simple example below, all three routers are running iBGP and advertising Network Layer Reachability Information (NRLI) to one another. The routers are also advertising their loopback interface as the next hop, which provides the ECMP between routers 2.2.2.2 and 3.3.3.3.


Figure 4: BGP Prefix SID Simple Example

Configuring Layer2 EVPN over Segment Routing MPLS

About Layer 2 EVPN

Ethernet VPN (EVPN) is a next generation solution that provides ethernet multipoint services over MPLS networks. EVPN operates in contrast to the existing Virtual Private LAN Service (VPLS) by enabling control-plane based MAC learning in the core. In EVPN, PEs participating in the EVPN instances learn customer MAC routes in control-plane using MP-BGP protocol. Control-plane MAC learning brings several

benefits that allow EVPN to address the VPLS shortcomings, including support for multihoming with per-flow load balancing.

In a data center network, the EVPN control plane provides:

- Flexible workload placement that is not restricted with the physical topology of the data center network. Therefore, you can place virtual machines (VM) anywhere within the data center fabric.
- Optimal East-West traffic between servers within and across data centers. East-West traffic between
 servers, or virtual machines, is achieved by most specific routing at the first hop router. First hop routing
 is done at the access layer. Host routes must be exchanged to ensure most specific routing to and from
 servers or hosts. VM mobility is supported by detecting new endpoint attachment when a new MAC
 address or the IP address is directly connected to the local switch. When the local switch sees the new
 MAC or the IP address, it signals the new location to rest of the network.
- Segmentation of Layer 2 and Layer 3 traffic, where traffic segmentation is achieved using MPLS encapsulation and the labels (per-BD label and per-VRF labels) act as the segment identifier.

Guidelines and Limitations for Layer 2 EVPN over Segment Routing MPLS

Layer 2 EVPN over segment routing MPLS has the following guidelines and limitations:

- Segment routing Layer 2 EVPN flooding is based on the ingress replication mechanism. MPLS core does not support multicast.
- ARP suppression is not supported.
- · Consistency checking on vPC is not supported.
- The same Layer 2 EVI and Layer 3 EVI cannot be configured together.
- Beginning with Cisco NX-OS Release 9.3(1), Layer 2 EVPN is supported on Cisco Nexus 9300-FX2 platform switches.
- Beginning with Cisco NX-OS Release 9.3(5), Layer 2 EVPN over segment routing MPLS is supported on Cisco Nexus 9300-GX and Cisco Nexus 9300-FX3 platform switches.

Configuring Layer 2 EVPN over Segment Routing MPLS

Before you begin

Do the following:

- You must install and enable the MPLS feature set using the **install feature-set mpls** and **feature-set mpls** commands.
- You must enable the MPLS segment routing feature.
- You must enable the nv overlay feature using the nv overlay command.
- You must enable EVPN control plane using the nv overlay evpn command.

Procedure

	Command or Action	Purpose
Ston 1	configure terminal	Enters global configuration mode
Step 1	Evennlei	Eners global configuration mode.
	Example:	
	switch(config)#	
Step 2	feature bgp	Enables BGP feature and configurations.
	Example:	
	<pre>switch(config)#feature bgp</pre>	
Step 3	install feature-set mpls	Enables MPLS configuration commands.
	Example:	
	<pre>switch(config)#install feature-set mpls</pre>	3
Step 4	feature-set mpls	Enables MPLS configuration commands.
	Example:	
	<pre>switch(config)#install feature-set mpls</pre>	3
Step 5	feature mpls segment-routing	Enables segment routing configuration
	Example:	commands.
	<pre>switch(config)#feature mpls segment-routing</pre>	
Step 6	feature mpls evpn	Enables EVPN over MPLS configuration
	Example:	commands. This command is mutually
	<pre>switch(config)#feature mpls evpn</pre>	exclusive with the reature-ity end command.
Step 7	feature nv overlay	Enables the NVE feature that is used for the
	Example:	segment routing Layer 2 EVPN.
	<pre>switch(config)#feature nv overlay</pre>	
Step 8	nv overlay evpn	Enables EVPN.
	Example:	
	<pre>switch(config)#nv overlay evpn</pre>	
Step 9	interface loopback Interface_Number	Configures the loopback interface for NVE.
	Example:	
	<pre>switch(config)#interface loopback 1</pre>	
Step 10	ip address address	Configures the IP address.
	Example:	
	<pre>switch(config-if)#ip address 192.168.15.1</pre>	

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	Command or Action	Purpose
Step 11	exit	Exits global address family configuration
	Example:	mode.
	<pre>switch(config-if)#exit</pre>	
Step 12	evpn	Enters the EVPN configuration mode.
	Example:	
	switch(config)#evpn	
Step 13	evi number	Configures Layer 2 EVI. If required, you can
	Example:	manually configure the RT based on the EVI
	switch(config-evpn)#evi 1000	that is generated automatically.
	switch(config-evpn-sr)#	
Step 14	encapsulation mpls	Enables MPLS encapsulation and ingress-replication
	Example:	ingross representation.
	<pre>switch(config-evpn)#encapsulation mpls</pre>	
Step 15	source-interface loopback Interface_Number	Specifies the NVE source interface.
	Example:	
	switch(config-evpn-nve-encap)#source-interface loopback 1	
Step 16	exit	Exits the configuration.
	Example:	
	<pre>switch(config-evpn-nve-encap)#exit</pre>	
Step 17	vrf context VRF_NAME	Configures the VRF.
	Example:	
	<pre>switch(config)#vrf context Tenant-A</pre>	
Step 18	evi EVI_ID	Configures L3 EVI.
	Example:	
	switch(config-vrf)#evi 30001	
Step 19	exit	Exits the configuration.
	Example:	
	<pre>switch(config-vrf)#exit</pre>	
Step 20	VLAN VLAN_ID	Configures VLAN.
	Example:	
	switch(config)#vlan 1001	
Step 21	evi auto	Configures L2 EVI.
	Example:	
		1

	Command or Action	Purpose
	switch(config-vlan)#evi auto	
Step 22	exit	
	Example:	
	<pre>switch(config-vlan)#exit</pre>	
Step 23	router bgp autonomous-system-number	Enters the BGP configuration mode.
	Example:	
	switch(config)#router bgp 1	
Step 24	address-family l2vpn evpn	Enables EVPN address family globally.
	Example:	
	<pre>switch(config-router)#address-family l2vpn evpn</pre>	
Step 25	neighbor address remote-as	Configures BGP neighbor.
	Exemple	
	Example.	
	192.169.13.1 remote as 2	
Step 26	address-family l2vpn evpn	Enables EVPN address family for neighbor.
	Example:	
	switch(config-router-neighbor)#address-family 12vpn evpn	
Step 27	encapsulation mpls	Enables MPLS encapsulation.
	Example:	
	<pre>switch(config-router-neighbor)#encapsulation mpls</pre>	
Step 28	send-community extended	Configures BGP to advertise extended
	Example:	community lists.
	switch(config-router-neighbor)#send-community extended	
Step 29	vrf VRF_NAME	Configures BGP VRF.
	Example:	
	<pre>switch(config-router)#vrf Tenant-A</pre>	
Step 30	exit	Exits the configuration.
	Example:	
	<pre>switch(config-router)#exit</pre>	

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Configuring VLAN for EVI

Procedure

	Command or Action	Purpose
Step 1	vlan number	Specifies the VLAN.
Step 2	evi auto	Creates a BD label for the VLAN. This label is used as an identifier for the VLAN across the segment routing Layer 2 EVPN.

Configuring the NVE Interface

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	interface loopback loopback_number	Associates the IP address with this loopback
	<pre>Example: switch(config)# interface loopback 1</pre>	interface and uses this IP address for the segment routing configuration.
Step 3	Step 3 ip address Specifies the	Specifies the IPv4 address family and enters
	Example:	router address family configuration mode.
	switch(config-if)#ip address 192.169.15.1/32	
Step 4	evpn	Enters EVPN configuration mode.
	Example:	
	switch(config)#evpn	
Step 5	encapsulation mpls	Enables MPLS encapsulation and
	Example:	ingress-replication.
	<pre>switch(config-evpn)# encapsulation mpls</pre>	
Step 6	source-interface loopback_number	Specifies the NVE source interface.
	Example:	
	switch(config-evpn-nve-encap)#source-interface loopback 1	

	Command or Action	Purpose
Step 7	exit	Exits segment routing mode and returns to the
	Example:	configuration terminal mode.
	switch(config)# exit	

Configuring EVI Under VRF

Procedure

	Command or Action	Purpose
Step 1	vrf context tenant	Create a VRF Tenant.
Step 2	evi number	Configure Layer 3 EVI under VRF.

Configuring Anycast Gateway

The fabric forwarding configuration is necessary only if the SVIs are configured in the anycast mode.

Procedure

	Command or Action	Purpose
Step 1	fabric forwarding anycast-gateway-mac 0000.aabb.ccdd	Configures the distributed gateway virtual MAC address.
Step 2	fabric forwarding mode anycast-gateway	Associates SVI with the Anycast Gateway under the interface configuration mode.

Advertising Labelled Path for the Loopback Interface

The loopback interface, advertised as Layer 2 EVPN endpoint should be mapped to a label index. Thereby BGP advertises MPLS labelled path for the same.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[no]router ospf process	Enables the OSPF mode.
	Example:	

	Command or Action	Purpose
	<pre>switch(config)# router ospf test</pre>	
Step 3	segment-routing	Configures the segment routing functionality
	Example:	under OSPF.
	<pre>switch(config-router)# segment-routing mpls</pre>	
Step 4	connected-prefix-sid-map	Enters a sub-mode where you can configure
	Example:	address-family specific mappings for local
	<pre>switch(config-sr-mpls)#</pre>	
	connected-prefix-sid-map	
Step 5	address-family ipv4	Specifies IPv4 address prefixes.
	Example:	
	<pre>switch(config-sr-mpls-conn)# address-family ipv4</pre>	
Step 6	1.1.1.1/32 index 100	Associates SID 100 with the address 1.1.1.1/32.
	Example:	
	<pre>switch(config-sr-mpls-conn-af)# 1.1.1.1/32 100</pre>	
Step 7	exit-address-family	Exits the address family.
	Example:	
	<pre>switch(config-sr-mpls-conn-af)# exit-address-family</pre>	

About SRv6 Static Per-Prefix TE

The SRv6 Static Per-Prefix TE feature allows you to map and advertise prefixes that at mapped to non-default VRFs. This feature allows you to advertise multiple prefixes in a single instance using the matching VRF route target and prevents the manual entry of each prefix.

In Cisco NX-OS Release 9.3(5), only one VNF can service a VM.

Configuring a SRv6 Static Per-Prefix TE

Before you begin

Do the following:

- You must install and enable the MPLS feature set using the **install feature-set mpls** and **feature-set mpls** commands.
- You must enable the MPLS segment routing feature.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	vrf context VRF_Name	Defines VRF and enters the VRF configuration
	Example:	mode.
	<pre>switch(config)# vrf context vrf_2_7_8</pre>	
Step 3	rd rd_format	Assign the RD to VRF.
	Example:	
	<pre>switch(config-vrf)# rd 2.2.2.0:2</pre>	
Step 4	address-family {ipv4 ipv6 }	Specifies either the IPv4 or the IPv6 address
	Example:	family for the VRF instance and enters the address family configuration mode
	<pre>switch(config-vrf)# address-family ipv4 unicast</pre>	address failing configuration mode.
Step 5	route-target import route-target-id	Configures the importing of routes to the VRF.
	Example:	
	<pre>switch(config-vrf)# route-target import 1:2</pre>	
Step 6	route-target import route-target-id evpn	Configures importing of routes that have a
	Example:	EVPN to the VRF
	<pre>switch(config-vrf)# route-target import 1:2 evpn</pre>	
Step 7	route-target export route-target-id	Configures the exporting of routes from the
	Example:	VRF.
	<pre>switch(config-vrf)# route-target export 1:2</pre>	
Step 8	route-target export route-target-id evpn	Configures exporting of routes that have a
	Example:	matching route target value from the VRF to the Laver 3 EVPN
	<pre>switch(config-vrf)# route-target export 1:2 evpn</pre>	the Layer 5 E vint.
Step 9	router bgp autonomous-system-number	Enables BGP and assigns the AS number to
	Example:	the local BGP speaker.
	switch(config)# router bgp 65000	

	Command or Action	Purpose
Step 10	router-id id	Configures the router ID.
	Example:	
	<pre>switch(config-router)# router-id 2.2.2.0</pre>	
Step 11	address-family l2vpn evpn	Enters global address family configuration
	Example:	mode for the Layer 2 VPN EVPN.
	<pre>switch(config-router-af)# address-family l2vpn evpn</pre>	
Step 12	neighbor ipv4-address remote-as	Configures the IPv4 address and AS number
	Example:	for a remote BGP peer.
	<pre>switch(config-router)# neighbor 7.7.7.0 remote-as 65000</pre>	
	<pre>switch(config-router-neighbor)#</pre>	
Step 13	update-source loopback number	Specifies the loopback number.
	Example:	
	<pre>switch(config-router-neighbor)# update-source loopback0</pre>	
Stop 1/	addross family 12ynn avnn	Enables EVDN address family for a paighbor
Slep 14		Enables EVPN address family for a heighbor.
	Example:	
	12vpn evpn	
Step 15	send-community extended	Configures BGP to advertise extended
	Example:	community lists.
	switch(config-router-neighbor)#send-community extended	
Step 16	encapsulation mpls	Enables MPLS encapsulation.
	Example:	
	<pre>switch(config-router-neighbor)#encapsulation mpls</pre>	
Step 17	exit	Exits the configuration.
	Example:	
	<pre>switch(config-router-neighbor)#exit</pre>	

Example

The following example shows how to configure RPM configuration in order to define the VRF VT.

```
rf context vrf_2_7_8
    rd 2.2.2.0:2
    address-family ipv4 unicast
    route-target import 0.0.1.1:2
    route-target import 0.0.1.1:2 evpn
```

```
route-target export 0.0.1.1:2
route-target export 0.0.1.1:2 evpn
ip extcommunity-list standard vrf_2_7_8-test permit rt 0.0.1.1:2
route-map Node-2 permit 4
match extcommunity vrf_2_7_8-test
set extcommunity color 204
```

About RD Auto

The auto-derived Route Distinguisher (rd auto) is based on the Type 1 encoding format as described in IETF RFC 4364 section 4.2 https://tools.ietf.org/html/rfc4364#section-4.2. The Type 1 encoding allows a 4-byte administrative field and a 2-byte numbering field. Within Cisco NX-OS, the auto derived RD is constructed with the IP address of the BGP Router ID as the 4-byte administrative field (RID) and the internal VRF identifier for the 2-byte numbering field (VRF ID).

The 2-byte numbering field is always derived from the VRF, but results in a different numbering scheme depending on its use for the IP-VRF or the MAC-VRF:

- The 2-byte numbering field for the IP-VRF uses the internal VRF ID starting at 1 and increments. VRF IDs 1 and 2 are reserved for the default VRF and the management VRF respectively. The first custom defined IP VRF uses VRF ID 3.
- The 2-byte numbering field for the MAC-VRF uses the VLAN ID + 32767, which results in 32768 for VLAN ID 1 and incrementing.

Example auto-derived Route Distinguisher (RD)

- IP-VRF with BGP Router ID 192.0.2.1 and VRF ID 6 RD 192.0.2.1:6
- MAC-VRF with BGP Router ID 192.0.2.1 and VLAN 20 RD 192.0.2.1:32787

About Route-Target Auto

The auto-derived Route-Target (route-target import/export/both auto) is based on the Type 0 encoding format as described in IETF RFC 4364 section 4.2 (https://tools.ietf.org/html/rfc4364#section-4.2). IETF RFC 4364 section 4.2 describes the Route Distinguisher format and IETF RFC 4364 section 4.3.1 refers that it is desirable to use a similar format for the Route-Targets. The Type 0 encoding allows a 2-byte administrative field and a 4-byte numbering field. Within Cisco NX-OS, the auto derived Route-Target is constructed with the Autonomous System Number (ASN) as the 2-byte administrative field and the Service Identifier (EVI) for the 4-byte numbering field.

2-byte ASN

The Type 0 encoding allows a 2-byte administrative field and a 4-byte numbering field. Within Cisco NX-OS, the auto-derived Route-Target is constructed with the Autonomous System Number (ASN) as the 2-byte administrative field and the Service Identifier (EVI) for the 4-byte numbering field.

Examples of an auto derived Route-Target (RT):

- IP-VRF within ASN 65001 and L3EVI 50001 Route-Target 65001:50001
- MAC-VRF within ASN 65001 and L2EVI 30001 Route-Target 65001:30001

For Multi-AS environments, the Route-Targets must either be statically defined or rewritten to match the ASN portion of the Route-Targets.

Note Auto derived Route-Targets for a 4-byte ASN are not supported.

4-byte ASN

The Type 0 encoding allows a 2-byte administrative field and a 4-byte numbering field. Within Cisco NX-OS, the auto-derived Route-Target is constructed with the Autonomous System Number (ASN) as the 2-byte administrative filed and the Service Identifier (EVI) for the 4-byte numbering field. With the ASN demand of 4-byte length and the EVI requiring 24-bit (3-bytes), the Sub-Field length within the Extended Community is exhausted (2-byte Type and 6-byte Sub-Field). As a result of the length and format constraint and the importance of the Service Identifiers (EVI) uniqueness, the 4-byte ASN is represented in a 2-byte ASN named AS_TRANS, as described in IETF RFC 6793 section 9 (https://tools.ietf.org/html/rfc6793#section-9). The 2-byte ASN 23456 is registered by the IANA (https://www.iana.org/assignments/iana-as-numbers-special-registry/iana-as-numbers-special-registry.xhtml) as AS_TRANS, a special purpose AS number that aliases 4-byte ASNs.

Example auto derived Route-Target (RT) with 4-byte ASN (AS TRANS):

- IP-VRF within ASN 65656 and L3EVI 50001 Route-Target 23456:50001
- MAC-VRF within ASN 65656 and L2EVI 30001 Route-Target 23456:30001

Configuring RD and Route Targets for BD

The Bridge Domain (BD) RD and Route Targets are automatically generated when you configure **evi auto** under the VLAN. To configure the BD RD and Route Targets manually, perform these steps:

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	evpn	Enters EVPN configuration mode.
	Example:	
	<pre>switch(config)# evpn</pre>	
Step 3	evi VLAN_ID	Specifies L2 EVI to configure RD/Route Target.
	Example:	
	<pre>switch(config-evpn)# evi 1001</pre>	
Step 4	rd rd_format	Configures RD.
	Example:	
	switch(config-evpn-evi-sr)# rd 192.1.1.1:33768	

	Command or Action	Purpose
Step 5	<pre>route-target both rt_format</pre>	Configures Route Target.
	Example:	
	<pre>switch(config-evpn-evi-sr)# route-target both 1:20001</pre>	

Configuring RD and Route Targets for VRF

The VRF RD and Route Targets are automatically generated when you configure the **evi**_*ID* under the VRF. To configure the VRF RD and Route Targets manually, perform these steps:

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	vrf context VRF_NAME	Configures the VRF.
	Example:	
	<pre>switch(config) # vrf context A</pre>	
Step 3	rd auto or rd_format	Configures RD.
	Example:	
	<pre>switch(config-vrf) # rd auto</pre>	
Step 4	address-family ipv4 unicast	Enables IPv4 address family.
	Example:	
	<pre>switch(config-vrf)# address-family ipv4 unicast</pre>	
Step 5	<pre>route-target both rt_format evpn</pre>	Configures Route Target.
	Example:	
	<pre>switch(config-vrf-af-ipv4)# route-target both 1:30001 evpn</pre>	

Configuration Examples for Layer 2 EVPN over Segment Routing MPLS

The following examples show the configuration for Layer 2 EVPN over Segment Routing MPLS:

```
install feature-set mpls
feature-set mpls
nv overlay evpn
feature bgp
feature mpls segment-routing
feature mpls evpn
```

```
feature interface-vlan
feature nv overlav
fabric forwarding anycast-gateway-mac 0000.1111.2222
vlan 1001
  evi auto
vrf context Tenant-A
  evi 30001
interface loopback 1
  ip address 192.168.15.1/32
interface vlan 1001
 no shutdown
  vrf member Tenant-A
  ip address 111.1.0.1/16
  fabric forwarding mode anycast-gateway
router bgp 1
  address-family 12vpn evpn
    neighbor 192.169.13.1
     remote-as 2
      address-family 12vpn evpn
        send-community extended
        encapsulation mpls
    vrf Tenant-A
evpn
  encapsulation mpls
    source-interface loopback 1
```

Configuring Proportional Multipath for VNF for Segment Routing

About Proportional Multipath for VNF for Segment Routing

In Network Function Virtualization Infrastructures (NFVi), service networks (Portable IPs) are routed by Virtual Network Functions (VNFs). The VNFs, also referred to as portable IP-Gateway (PIP-GW) routes the data packets to and from the VMs in the VNF. The Proportional Multipath for VNF for Segment Routing feature enables advertising the VNF of a service network (PIP) in the EVPN address-family. The IP address of the VNF is encoded in the "Gateway-IP Address" field of the EVPN IP Prefix Route NLRI advertisement of a service network.

By advertising the IP address of the VNFs, ingress nodes in the EVPN fabric recursively resolve the VNF IP address to the leaf attached to the VNF, which could be the same node that advertises the service network (PIP).

Route-injectors are BGP protocols that inject routes in the IPv4 or IPv6 AF. In this case, the route-injector injects routes to the VMs whose next hop is set as VNFs.

Unlike a route-injector, VNFs can participate in a routing protocol to advertise the VM reachability. The supported protocols are eBGP, IS-IS, and OSPF.

Enabling Proportional Multipath for VNF for Segment Routing

You can enable the Proportional Multipath for VNF for Segment Routing feature to redistribute routes for IGP or static routes by preserving the next-hop paths. You can then export and advertise the gateway-IP for the reoriginated EVPN type-5 routes.

In Cisco NX-OS Release 9.3(5), only one VNF can service a VM.

Before you begin

Do the following:

- Install and enable the MPLS feature set using the install feature-set mpls and feature-set mpls commands.
- Enable the MPLS segment routing feature.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enter global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map export-l2evpn-rtmap permit 10	< <need description="">></need>
	Example:	
	<pre>switch(config)# route-map export-l2evpn-rtmap permit 10</pre>	
Step 3	match ip address prefix-list pip-pfx-list	Defines the prefixes that must be advertised
	Example:	with PIP-GW as the gateway.
	<pre>switch(config-route-map)# match ip prefix-list vm-pfx-list</pre>	
Step 4	set evpn gateway-ip use-nexthop	Defines specific routes to advertise the
	Example:	gateway-ip.
	<pre>switch(config-route-map)# set evpn gateway-ip use-nexthop</pre>	
Step 5	vrf context VRF_Name	Applies the route map to the vrf context.
	Example:	
	<pre>switch(config-route-map)# vrf context vrf switch(config-route-map)# address-family ipv4 unicast switch(config-route-map)# export map export-l2evpn-rtmap</pre>	

	Command or Action	Purpose
Step 6	address-family ipv4 unicast	Applies the route map to the vrf context.
	Example:	
	<pre>switch(config-route-map)# address-family ipv4 unicast switch(config-route-map)# export map export-l2evpn-rtmap</pre>	
Step 7	export map export-l2evpn-rtmap	Applies the route map to the vrf context.
	Example:	
	<pre>switch(config-route-map)# export map export-l2evpn-rtmap</pre>	
Step 8	router bgp number	Configure BGP.
	Example:	
	<pre>switch(config)# router bgp 100</pre>	
Step 9	vrf VRF_Name	Applies the route map to the vrf context.
	Example:	
	<pre>switch(config-route-map)# vrf vrf3</pre>	
Step 10	address-family ipv4 unicast	Configure address family for IPv4.
	Example:	
	<pre>switch(config-router)# address-family ipv4 unicast</pre>	
Step 11	export-gateway-ip	Exports and advertises the gateway-ip to
	Example:	reconnect the EVPN type-5 routes.
	<pre>switch(config-route-map)# export-gateway-ip</pre>	Note The export gateway-ip and set the EVPN gateway configurations can be performed simultaneously. If you configure them simultaneously, all prefixes are exported with the gateway-ip.

vPC Multihoming

About Multihoming

Cisco Nexus platform switches support vPC-based multihoming, where a pair of switches act as a single device for redundancy and both switches function in active mode. With Cisco Nexus platform switches in an EVPN environment, there are two solutions that support Layer 2 multihoming; these solutions are based on

the traditional vPC (emulated or virtual IP address), where the MCT link is required and the BGP EVPN techniques.

While using the BGP EVPN control plane, each vPC pair uses a common virtual IP (VIP) to provide active/active redundancy. BGP EVPN based multihoming further provides fast convergence during certain failure scenarios, that otherwise cannot be achieved without a control protocol (data plane flood and learn).

Per-BD label on vPC Peers

To ensure that the vPC peers have the same per-BD label, you must specify the per-BD label to have the following value:

Label value = Label_base + VLAN_ID

The label base is configured on the same vPC peers. Currently, the VLAN configuration is identical on both the vPC peers, which ensures that both vPC peers have the same label.

In Cisco NX-OS Release 9.3(1), configuring the per-BD label is not supported. This release supports only evi auto.

Per-VRF label on vPC Peers

To ensure that the vPC peers have the same per-VRF label, you must specify the per-VRF label to have the following value:

Label value = Label base + vrf allocate index

To configure the allocate-index for the vPC peers, do the following:

```
Router bgp 1
vrf Tenant_A
allocate-index 11
```

Configuring Backup Link

The backup link needs to be configured between the vPC peers. This link can be any Layer 3 link which is parallel to MCT.

Example

```
interface vlan 100
    ip add 10.1.1.1/24
    mpls ip forwarding
< enable underlay protocol >
```

Guidelines and Limitations for vPC Multihoming

vPC multihoming has the following guidelines and limitations:

- ESI-based multihoming is not supported.
- The physical and virtual secondary IP addresses should be both advertised via the MPLS labeled path.
- vPC consistency checking is not supported for the per-BD label configuration.

Configuration Examples for vPC Multihoming

This example shows the configuration for vPC multihoming:

```
    vPC Primary
```

```
interface loopback1
   ip address 192.169.15.1/32
   ip address 192.169.15.15/32 secondary
 evpn
   encapsulation mpls
    source-interface loopback1
 vlan 101
  evi auto
 vrf context A
   evi 301
 router bgp 1
   vrf A
     allocate-index 1001

    vPC Secondary

 interface loopback1
   ip address 192.169.15.2/32
   ip address 192.169.15.15/32 secondary
 evpn
   encapsulation mpls
    source-interface loopback1
 vlan 101
   evi auto
 vrf context A
   evi 301
```

router bgp 1 vrf A allocate-index 1001

Configuring Layer 3 EVPN and Layer 3 VPN over Segment Routing MPLS

This section describes tasks to configure the Layer 3 EVPN and stitching of L3 EVPN and L3VPN router. Perform the following tasks to complete the configuration:

Configuring VRF and Route Targets for Import and Export Rules

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
Step 2	vrf vrf-name	Defines a VPN routing and forwarding (VRF) instance and enters the VRF configuration mode.
Step 3	rd auto	Automatically assigns a unique route distinguisher (RD) to VRF.
Step 4	address-family { ipv4 ipv6 } unicast	Specifies either the IPv4 or IPv6 address family for the VRF instance and enters address family configuration submode.
Step 5	route-target import route-target-id	Configures importing of routes to the VRF from the L3VPN BGP NLRIs that have the matching route-target value.
Step 6	route-target export route-target-id	Configures exporting of routes from the VRF to the L3VPN BGP NLRIs and assigns the specified route-target identifiers to the L3VPN BGP NLRIs.
Step 7	route-target import route-target-id evpn	Configures importing of routes from the L3 EVPN BGP NLRI that have the matching route-target value.
Step 8	route-target export route-target-id evpn	Configures exporting of routes from the VRF to the L3 EVPN BGP NLRIs and assigns the specified route-target identifiers to the BGP EVPN NLRIs.

Configuring BGP EVPN and Label Allocation Mode

You can use MPLS tunnel encapsulation using the **encapsulation mpls** command. You can configure the label allocation mode for the EVPN address family. The default tunnel encapsulation in EVPN for IP Route type in NX-OS is VXLAN.

Advertisement of (IP or Label) bindings from a Cisco Nexus 9000 Series switch via BGP EVPN enables a remote switch to send the routed traffic to that IP using the label for that IP to the switch that advertised the IP over MPLS.

The IP prefix route (Type-5) is:

• Type-5 route with MPLS encapsulation

```
RT-5 Route - IP Prefix
```

```
RD: L3 RD
IP Length: prefix length
IP address: IP (4 bytes)
Label1: BGP MPLS Label
Route Target
RT for IP-VRF
```

The default label allocation mode is per-VRF for Layer 3 EVPN over MPLS.

Complete the following steps to configure BGP EVPN and label allocation mode:

Before you begin

You must install and enable the MPLS feature set using the **install feature-set mpls** and **feature-set mpls** commands.

You must enable the MPLS segment routing feature.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
Step 2	<pre>[no] router bgp autonomous-system-number Example: switch(config) # router bgp 64496 switch(config-router) #</pre>	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format. Use the no option with this command to remove the BGP process and the associated configuration.
Step 3	Required: address-family 12vpn evpn Example: switch(config-router)# address-family 12vpn evpn switch(config-router-af)#	Enters global address family configuration mode for the Layer 2 VPN EVPN.
Step 4	Required: exit Example: switch(config-router-af)# exit switch(config-router)#	Exits global address family configuration mode.
Step 5	<pre>neighbor ipv4-address remote-as autonomous-system-number Example: switch(config-router)# neighbor 10.1.1.1 remote-as 64497 switch(config-router-neighbor)#</pre>	Configures the IPv4 address and AS number for a remote BGP peer.

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	Command or Action	Purpose
Step 6	address-family l2vpn evpn	Advertises the labeled Layer 2 VPN EVPN.
	Example:	
	<pre>switch(config-router-neighbor)# address-family 12vpn evpn switch(config-router-neighbor-af)#</pre>	
Step 7	encapsulation mpls	Enables BGP EVPN address family and sends EVPN type-5 route update to the neighbors.
	<pre>router bgp 100 address-family 12vpn evpn neighbor NVE2 remote-as 100 address-family 12vpn evpn send-community extended encapsulation mpls vrf foo address-family ipv4 unicast advertise 12vpn evpn BGP segment routing configuration: router bgp 100 address-family ipv4 unicast network 200.0.0.1/32 route-map label_index_pol_100 network 101.0.0.0/24 route-map label_index_pol_103 allocate-label all neighbor 192.168.5.6 remote-as 20 address-family ipv4 labeled-unicast send-community extended</pre>	Note The default tunnel encapsulation in EVPN for the IP route type in NX-OS is VXLAN. To override that, a new CLI is introduced to indicate MPLS tunnel encapsulation.
Step 8	<pre>vrf <customer_name></customer_name></pre>	Configures the VRF.
Step 9	address-family ipv4 unicast	Enters global address family configuration mode for the IPv4 address family.
Step 10	advertise l2vpn evpn	Advertises Layer 2 VPN EVPN.
Step 11	redistribute direct route-map DIRECT_TO_BGP	Redistributes the directly connected routes into BGP-EVPN.
Step 12	label-allocation-mode per-vrf	Sets the label allocation mode to per-VRF. If you want to configure the per-prefix label mode, use the no label-allocation-mode per-vrf CLI command.
		For the EVPN address family, the default label allocation is per-vrf, compared to per-prefix mode for the other address-families where the

Command or Action	Purpose
	label allocation CLI is supported. No form of CLI is displayed in the running configuration.

Example

See the following example for configuring per-prefix label allocation:

```
router bgp 65000
    [address-family 12vpn evpn]
   neighbor 10.1.1.1
       remote-as 100
        address-family 12vpn evpn
        send-community extended
    neighbor 20.1.1.1
       remote-as 65000
       address-family 12vpn evpn
       encapsulation mpls
       send-community extended
    vrf customer1
        address-family ipv4 unicast
           advertise l2vpn evpn
           redistribute direct route-map DIRECT_TO_BGP
           no label-allocation-mode per-vrf
```

Configuring BGP Layer 3 EVPN and Layer 3 VPN Stitching

In order to configure the stitching on the same router, configure the layer 3 VPN neighbor relationship and router advertisement.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[no] router bgp autonomous-system-number	Enables BGP and assigns the AS number to
	Example:	the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form
	<pre>switch# configure terminal switch(config)# router bgp 64496 switch(config-router)#</pre>	of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 3	address-family {vpnv4 vpnv6} unicast	Enters global address family configuration
	Example:	mode for the Layer 3 VPNv4 or VPNv6.

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	Command or Action	Purpose
	<pre>switch(config-router)# address-family vpnv4 unicast switch(config-router-af)# address-family vpnv6 unicast switch(config-router-af)#</pre>	
Step 4	<pre>exit Example: switch(config-router-af)# exit switch(config-router)#</pre>	Exits global address family configuration mode.
Step 5	<pre>neighbor ipv4-address remote-as autonomous-system-number Example: switch(config-router)# neighbor 20.1.1.1 remote-as 64498</pre>	Configures the IPv4 address and AS number for a remote BGP L3VPN peer.
Step 6	<pre>address-family {vpnv4 vpnv6} unicast Example: switch(config-router)# address-family vpnv4 unicast switch(config-router-af)# address-family vpnv6 unicast switch(config-router-af)#</pre>	Configure the neighbor address-family for VPNv4 or VPNv6.
Step 7	send-community extended	Enables BGP VPN address family
Step 8	import l2vpn evpn reoriginate	Configures import of routing information from the Layer 3 VPN BGP NLRIs that has route target identifier matching the normal route target identifier and exports this routing information after re-origination that assigns it with stitching route target identifier, to the BGP EVPN neighbor.
Step 9	<pre>neighbor ipv4-address remote-as autonomous-system-number Example: switch(config-router) # neighbor 10.1.1.1 remote-as 64497 switch(config-router-neighbor) #</pre>	Configures the IPv4 address and AS number for a remote Layer 3 EVPN BGP peer.
Step 10	address-family {l2vpn evpn Example: switch(config-router-neighbor)# address-family l2vpn evpn switch(config-router-neighbor-af)#	Configure the neighbor address-family for Layer 3 EVPN.
Step 11	import vpn unicast reoriginate	Enables import of routing information from BGP EVPN NLRIs that has route target identifier matching the stitching route target

	Command or Action	Purpose
		identifier and exports this routing information after re-origination to the Layer 3 VPN BGP neighbor.
Step 12	vrf < <i>customer_name</i> >	Configures the VRF.
Step 13	address-family ipv4 unicast	Enters global address family configuration mode for the IPv4 address family.
Step 14	advertise l2vpn evpn	Advertises Layer 2 VPN EVPN.

Example

```
vrf context Customer1
    rd auto
    address-family ipv4 unicast
       route-target import 100:100
       route-target export 100:100
        route-target import 100:100 evpn
        route-target export 100:100 evpn
segment-routing
   mpls
      global-block 11000 20000
      connected-prefix-sid
         address-family ipv4 unicast
         200.0.0.1 index 101
T.
int lo1
  ip address 200.0.0.1/32
1
interface e1/13
 description "MPLS interface towards Core"
  ip address 192.168.5.1/24
 mpls ip forwarding
 no shut
router bgp 100
address-family ipv4 unicast
allocate-label all
address-family ipv6 unicast
address-family 12vpn evpn
address-family vpnv4 unicast
address-family vpnv6 unicast
neighbor 10.0.0.1 remote-as 200
   update-source loopback1
    address-family vpnv4 unicast
      send-community extended
      import 12vpn evpn reoriginate
    address-family vpnv6 unicast
      import l2vpn evpn reoriginate
      send-community extended
  neighbor 20.0.0.1 remote-as 300
    address-family 12vpn evpn
      send-community extended
      import vpn unicast reoriginate
      encapsulation mpls
  neighbor 192.168.5.6 remote-as 300
```

```
address-family ipv4 labeled-unicast
vrf Customer1
address-family ipv4 unicast
advertise l2vpn evpn
address-family ipv6 unicast
advertise l2vpn evpn
```

Configuring the Features to Enable Layer3 EVPN and Layer3 VPN

Before you begin

Install the VPN Fabric license.

Make sure that the feature interface-vlan command is enabled.

Procedure

	Command or Action	Purpose
Step 1	feature bgp	Enables BGP feature and configurations.
Step 2	install feature-set mpls	Enables MPLS configuration commands.
Step 3	feature-set mpls	Enables MPLS configuration commands.
Step 4	feature mpls segment-routing	Enables segment routing configuration commands.
Step 5	feature mpls evpn	Enables EVPN over MPLS configuration commands. This command is mutually exclusive with the feature-nv CLI command.
Step 6	feature mpls l3vpn	Enables EVPN over MPLS configuration commands. This command is mutually exclusive with the feature-nv CLI command.

Configuring BGP L3 VPN over Segment Routing

Before you begin

You must install and enable the MPLS feature set using the **install feature-set mpls** and **feature-set mpls** commands.

You must enable the MPLS segment routing feature.

You must enable the MPLS L3 VPN feature using the feature mpls l3vpn command.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
-	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	<pre>[no] router bgp autonomous-system-number Example: switch(config) # router bgp 64496 switch(config-router) #</pre>	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format. Use the no option with this command to remove the BGP process and the associated configuration.
Step 3	<pre>address-family {vpnv4 vpnv6} unicast Example: switch(config-router)# address-family vpnv4 unicast switch(config-router-af)# address-family vpnv6 unicast switch(config-router-af)#</pre>	Enters global address family configuration mode for the Layer 3 VPNv4 or VPNv6.
Step 4	[no] allocate-label option-b	Disables the inter-AS option-b
Step 5	Required: exit Example: switch(config-router-af)# exit switch(config-router)#	Exits global address family configuration mode.
Step 6	<pre>neighbor ipv4-address remote-as autonomous-system-number Example: switch(config-router)# neighbor 20.1.1.1 remote-as 64498 switch(config-router-neighbor)#</pre>	Configures the IPv4 address and AS number for a remote BGP L3VPN peer.
Step 7	address-family {vpnv4 vpnv6 } unicast Example: switch(config-router-neighbor)# address-family vpnv4 unicast switch(config-router-neighbor-af)#	Configure the neighbor address-family for VPNv4 or VPNv6.
Step 8	send-community extended	Enables BGP VPN address family.
Step 9	vrf <customer_name></customer_name>	Configures the VRF.
Step 10	allocate-index x	Configure the allocate-index.

	Command or Action	Purpose
Step 11	address-family ipv4 unicast	Enters global address family configuration mode for the IPv4 address family.
Step 12	redistribute direct route-map DIRECT_TO_BGP	Redistributes the directly connected routes into BGP-L3VPN.

BGP Layer3 VPN Over SRTE

This feature enables the traffic engineering capabilities towards the Segment Routing core for Data-Center Interconnect (DCI)/WAN Edge deployments. It enables DCI hand off (VxLAN to L3VPN based on SR and vice-versa) and can use SRTE capabilities in SR Core so that SLA's can be achieved by different traffic classes. SRTE capabilities can be applied on DCI or edge routers by applying SR-Policy for L3VPN prefixes. L3VPN prefixes can be advertised(by DCI or Edge nodes) after setting extended community color and BGP L3VPN neighbor can apply SR-policy based on that color to create SRTE. Listed below are the configurations for configuring extended community color on L3VPN prefixes.

Guidelines and Limitations for Configuring Layer 3 VPN Over SRTE

Beginning with Cisco NX-OS Release 10.1(2), segment routing traffic engineering is supported over Layer 3 VPN on Cisco Nexus 9300-FX3, N9K-C9316D-GX, N9K-C93180YC-FX, N9K-C93240YC-FX2, and N9K-C9364C platform switches.

The limitations for this feature are as follows:

- UnderLay IPv6 is not supported. SRv6 is the alternate.
- PCE using BGP underlay is not supported, due to PCE's shortcoming on BGP only fabric.
- OSPF-SRTE with PCE is not supported, due NXOS's inability to advertise LSA in BGP-LS.
- Supports total SRTE policy scale of 1000, BGP VPNv4 32K routes, BGP VPNV6 32k routes, and underlay SR prefixes of 1000.

Beginning with Cisco NX-OS Release 10.2(3)F, the option of color-only (CO) bits is added in route map. If the value of the CO bits change for a given prefix that is using an SRTE policy, BGP will delete the old policy and add a new policy.

Configuring Extended Community Color

This section includes the following topics:

Configuring Extended Community Color at the Ingress Node

To configure extended community color at the ingress node when the prefix is announced by the ingress node, where the SRTE policy is instantiated, perform the following steps:

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map map-name	Creates a route map or enters route-map
	Example:	configuration mode for an existing route map.
	<pre>switch(config)# route-map ABC switch(config-route-map)</pre>	
Step 3	set extcommunity color color-num	Sets BGP extcommunity attribute for color
	Example:	extended community.
	<pre>switch(config-route-map)# set extcommunity color 20 switch(config-route-map)#</pre>	
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	[no] router bgp autonomous-system-number	Enables BGP and assigns the AS number to the
	Example:	16-bit integer or a 32-bit integer in the form of
	<pre>switch(config)# router bgpl switch(config-router)#</pre>	a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	neighbor ip-address	Adds an entry to the BGP or multiprotocol BGP
	Example:	neighbor table. The ip-address argument
	<pre>switch(config-router)# neighbor 200.105.201.1</pre>	decimal notation.
	<pre>switch(config-router-neighbor) #</pre>	
Step 7	address-family vpnv4/vpnv6 unicast	Enters router address-family configuration mode
	Example:	for the vpnv4/vpnv6 address family type.
	<pre>switch(config-router-neighbor)# address family unput/unput/ unicest</pre>	
	switch(config-router-neighbor-af)#	
Step 8	route-map map-name in	Applies the configured BGP policy to incoming
	Example:	routes.

Command or Action	Purpose
<pre>switch(config-router-neighbor-af)# route-map ABC in switch(config-router-neighbor-af)#</pre>	The map-name can be any case-sensitive, alphanumeric string up to 63 characters.

Configuring Extended Community Color at the Egress Node

To configure extended community color at the egress node when the prefix is announced by the egress node, perform the following steps:

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map map-name	Creates a route map or enters route-map
	Example:	configuration mode for an existing foute map.
	<pre>switch(config)# route-map ABC switch(config-route-map)</pre>	
Step 3	set extcommunity color color-num	Sets BGP extcommunity attribute for color
	Example:	extended community.
	<pre>switch(config-route-map)# set extcommunity color 20 switch(config-route-map)#</pre>	
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	[no] router bgp autonomous-system-number	Enables BGP and assigns the AS number to the
	Example:	local BGP speaker. The AS number can be a
	<pre>switch(config)# router bgpl switch(config-router)#</pre>	a higher 16-bit decimal number and a lowe 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	neighbor ip-address	Adds an entry to the BGP or multiprotocol BGP
	Example:	neighbor table. The ip-address argument
	<pre>switch(config-router)# neighbor 209.165.201.1 switch(config-router-neighbor)#</pre>	decimal notation.

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	Command or Action	Purpose
Step 7	address-family vpnv4/vpnv6 unicast Example:	Enters router address-family configuration mode for the vpnv4/vpnv6 address family type.
	<pre>switch(config-router-neighbor)# address-family vpnv4/vpnv6 unicast switch(config-router-neighbor-af)#</pre>	
Step 8	route-map map-name out	Applies the configured BGP policy to outgoin
	Example:	routes.
	<pre>switch(config-router-neighbor-af)# route-map ABC out switch(config-router-neighbor-af)#</pre>	The map-name can be any case-sensitive, alphanumeric string up to 63 characters.

Configuring Extended Community Color for Network/Redistribute Command at the Egress Node

To configure extended community color for the network/redistribute command at the egress node when the prefix is announced by the egress node, perform the following steps:

Procedure

	Command or Action	Purpose
Step 1	<pre>configure terminal Example: switch# configure terminal switch(config)#</pre>	Enters global configuration mode.
Step 2	<pre>route-map map-name Example: switch(config)# route-map ABC switch(config-route-map)</pre>	Creates a route map or enters route-map configuration mode for an existing route map.
Step 3	<pre>set extcommunity color color-num Example: switch(config-route-map)# set extcommunity color 20 switch(config-route-map)#</pre>	Sets BGP extcommunity attribute for color extended community.
Step 4	<pre>exit Example: switch(config-route-map)# exit switch(config)#</pre>	Exits route-map configuration mode.
Step 5	<pre>[no] router bgp autonomous-system-number Example: switch(config)# router bgp1; switch(config-router)#</pre>	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.

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	Command or Action	Purpose
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	<pre>vrf <customer_name></customer_name></pre>	Configures the VRF.
Step 7	<pre>address-family ipv4 unicast Example: switch(config-router-vrf)# address-family ipv4 unicast switch(config-router-af)#</pre>	Specifies the IPv4 address family for the VRF instance and enters the address family configuration mode.
Step 8	<pre>redistribute static route-map map-name out Example: switch(config-router-vrf-af)# redistribute static route-map ABC switch(config-router-af)#</pre>	Redistributes static routes into BGP. The map-name can be any case-sensitive, alphanumeric string up to 63 characters.
Step 9	<pre>network ip-prefix [route-map map-name] Example: switch(config-router-vrf-af)# network 1.1.1.1/32 route-map ABC switch(config-router-af-network)#</pre>	Specifies a network as local to this autonomous system and adds it to the BGP routing table.

Configuring Segment Routing MPLS and GRE Tunnels

GRE Tunnels

You can use generic routing encapsulation (GRE) as the carrier protocol for a variety of passenger protocols.

The following figure shows the IP tunnel components for a GRE tunnel. The original passenger protocol packet becomes the GRE payload and the device adds a GRE header to the packet. The device then adds the transport protocol header to the packet and transmits it.

Figure 5: GRE PDU



Segment Routing MPLS and GRE

Beginning Cisco NX-OS Release 9.3(1), you can configure both, segment routing MPLS and generic routing encapsulation (GRE) on a Cisco Nexus device. Both these technologies operate seamlessly. All MPLS traffic can be forwarded to the GRE tunnel after the MPLS tunnel termination. Similarly, you can forward all traffic from the GRE tunnel to the MPLS cloud after the GRE termination.

All PE routers can initiate, forward, or terminate the GRE traffic from or to another GRE cloud. Similarly, all tunnel transit or tunnel end nodes can configure MPLS tunnel encapsulation.

When both, the tunnel and segment routing is enabled on the Cisco Nexus 9000 switches, the following is the TTL behavior is for the respective flows:

- Incoming IP traffic, egresses with GRE header, the TTL value in the GRE header is one less than the TTL value of the incoming IP packet.
- Incoming IP traffic, egresses with MPLS header, the TTL value in the MPLS header is one less than the TTL value of the incoming IP packet.
- Incoming GRE traffic, egresses with MPLS header, the TTL value in the MPLS header is default (255).
- Incoming MPLS traffic, egresses with GRE header, the TTL value in the GRE header is default (255).

Guidelines and Limitations for Segment Routing MPLS and GRE

Segment routing MPLS and GRE have the following guidelines and limitations:

- Ingress stats are not supported for tunnel packets.
- Supported with either default or template-mpls-heavy mode only.
- MPLS segment routing is not supported on the tunnel interfaces.
- Due to a hardware limitation on the modular switches, the tunnel Tx traffic is not supported if the egress interface for the tunnel destination IP address is over the Cisco Nexus 9300-FX/FX2 platform switches.
- Maximum four GRE tunnels are supported.
- Beginning with Cisco NX-OS Release 9.3(3), you can configure both, segment routing MPLS and GRE on Cisco Nexus 9300-GX platform switches.
- Tunnel Rx packet counters do not work when both segment routing MPLS and GRE coexist.

Configuring Segment Routing MPLS and GRE

You can enable MPLS segment routing as long as mutually-exclusive MPLS features such as static MPLS are not enabled.

Before you begin

You must install and enable the MPLS feature set using the **install feature-set mpls** and **feature-set mpls** commands.

You must enable the tunneling feature using the **feature tunnel** command.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[no] feature segment-routing	Enables the MPLS segment routing feature.
	Example:	The no form of this command disables the MPLS segment routing feature
	<pre>switch(config)# feature segment-routing</pre>	
Step 3	(Optional) show running-config inc 'feature segment-routing'	Displays the status of the MPLS segment routing feature.
	Example:	
	<pre>switch(config)# show running-config inc 'feature segment-routing'</pre>	
Step 4	(Optional) copy running-config startup-config	Copies the running configuration to the startup configuration.
	Example:	
	switch(config)# copy running-config startup-config	
Step 5	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 6	feature tunnel	Allows the creation of a new tunnel interface.
	Example:	To disable the tunnel interface feature, use the
	<pre>switch(config)# feature tunnel switch(config-if)#</pre>	no form of this command.
Step 7	switch(config)# interface tunnel number	Enters a tunnel interface configuration mode.
Step 8	<pre>switch(config-if)# tunnel mode {gre ip }</pre>	Sets this tunnel mode to GRE.
		The gre and ip keywords specify that GRE encapsulation over IP will be used.
Step 9	tunnel source {ip-address interface-name}	Configures the source address for this IP
	Example:	tunnel. The source can be specified by IP
	<pre>switch(config-if)# tunnel source ethernet 1/2</pre>	address of logical interface fiame.

	Command or Action	Purpose
Step 10	<pre>tunnel destination {ip-address host-name} Example: switch(config-if)# tunnel destination 192.0.2.1</pre>	Configures the destination address for this IP tunnel. The destination can be specified by IP address or logical host name.
Step 11	<pre>tunnel use-vrf vrf-name Example: switch(config-if)# tunnel use-vrf blue</pre>	
Step 12	ipv6 address IPv6 address	<pre>switch(config-if)# 10.1.1.1 Configures the IPv6 address. Note The tunnel source and the destination addresses are still the same (IPv4 address.)</pre>
Step 13	(Optional) switch(config-if)# show interface tunnel <i>number</i>	Displays the tunnel interface statistics.
Step 14	switch(config-if)# mtu value	Sets the maximum transmission unit (MTU) of IP packets sent on an interface.
Step 15	(Optional) switch(config-if)# copy running-config startup-config	Saves the change persistently through reboots and restarts by copying the running configuration to the startup configuration.

Verifying the Segment Routing MPLS and GRE Configuration

To display the segment routing MPLS and GRE configuration, perform one of the following tasks:

Command	Purpose
show segment-routing mpls	Displays segment routing mpls information

Verifying SR-TE for Layer 3 EVPN

The ODN verifications are based on L3VPN VRF prefixes.

1. Verify that the PCEP session between R1 (headend and PCE server) is established.

```
R1# show srte pce ipv4 peer
```

```
PCC's peer database:
------
Remote PCEP conn IPv4 addr: 58.8.8.8
Local PCEP conn IPv4 addr: 51.1.1.1
Precedence: 0
State: up
```

2. Verify BGP LS and BGP EVPN session on R1, R3, and R6 using the following commands:

- Show bgp l2vpn evpn summary
- Show bgp link-state summary
- 3. Verify that the R1 (headend) has no visibility to the R6 loopback address.

```
Rl# show ip route 56.6.6.6
IP Route Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>
56.6.6.6/32, ubest/mbest: 1/0
    *via Null0, [1/0], 1d02h, static
```

4. Verify that the VRF prefix is injected via MP-BGP in a R1 VRF SR routing table.

```
Rl# show ip route vrf sr
106.107.4.1/32, ubest/mbest: 1/0
    *via binding label 100534%default, [20/0], 1d01h, bgp-6503, external, tag 6500
(mpls-vpn)
```

5. Verify the SR-TE Tunnel.

```
R1# show srte policy
Policy name: 51.1.1.1|1001
   Source: 51.1.1.1
   End-point: 56.6.6.6
   Created by: bgp
   State: UP
   Color: 1001
   Insert: FALSE
   Re-opt timer: 0
   Binding-sid Label: 100534
   Policy-Id: 2
   Flags:
   Path type = MPLS
                             Path options count: 1
    Path-option Preference:100 ECMP path count: 1
            PCE
                   Weighted: No
     1.
       Delegated PCE: 58.8.8.8
               Index: 1
                                       Label: 101104
               Index: 2
                                       Label: 201102
                                       Label: 201103
               Index: 3
```

Verifying the Segment Routing Configuration

To display the segment routing configuration, perform one of the following tasks:

Command	Purpose
show bgp ipv4 labeled-unicast <i>prefix</i>	Displays the advertised label index and the selected local label for the specified IPv4 prefix.
show bgp paths	Displays the BGP path information, including the advertised label index.

Command	Purpose
show mpls label range	Displays the configured SRGB range of labels.
show route-map [map-name]	Displays information about a route map, including the label index.
show running-config rpm	Displays information about Route Policy Manager (RPM).
show running-config inc 'feature segment-routing'	Displays the status of the MPLS segment routing feature.
show ip ospf neighbors detail	Displays the list of OSPFv2 neighbors and the adjacency SID allocated, along with the corresponding flags.
show ip ospf database opaque-area	Displays the LSAs for the adjacency SID.
show ip ospf segment-routing adj-sid-database	Displays all locally allocated adjacency SIDs.
show running-config segment-routing	Displays the status of the segment routing feature.
show srte policy	Displays only the authorized policies.
show srte policy [all]	Displays the list of all policies available in the SR-TE.
show srte policy [detail]	Displays the detailed view of all the requested policies.
show srte policy <name></name>	Filters the SR-TE policy with the name and displays the list of all policies available with that name in the SR-TE.
	Note This command has the autocomplete feature for the policy-name. To use this feature, add a question mark or press TAB.
<pre>show srte policy color <color> endpoint <endpoint></endpoint></color></pre>	Displays the SR-TE policy for the color and endpoint. Note This command has the autocomplete feature for color and endpoint. To use this feature, add a question mark or press TAB.
show srte policy fh	Displays the set of first hops.
show segment-routing mpls clients	Displays the clients registered with the SR-APP.
show segment-routing mpls details	Displays detailed information.
show segment-routing ipv4	Displays the information for the IPv4 address family.
show segment-routing mpls	Displays segment routing mpls information
Command	Purpose
--	---
show segment-routing ipv4 connected-prefix-sid	Displays the MPLS label range for the SRGB.
	Note This command is only available in Cisco NX-OS Release 9.3(1).
show ip ospf process	Displays the OSPF mode.
show ip ospf process segment-routing sid-database	Displays the segment routing database details.
show ip ospf <i>process</i> segment-routing global block	Displays the segment routing global block information.
show nve evi	Displays the status of the EVIs.
show nve peer mpls	Displays the status of the segment routing peers.
show nve adjacency mpls	Displays the status of the peer adjacencies.

Configuring SRTE Explicit-Path Endpoint Substitution

This chapter contains information on how to configure the SRTE Explicit-path Endpoint Substitution feature.

About SRTE Explicit-path Endpoint Substitution

The SRTE Explicit-path Endpoint Substitution feature allows the user to define an explicit path as a series of MPLS labels, like a regular explicit path, but allows a placeholder to be added in the series that represents the policy endpoint label. The placeholder is represented by the **policy-endpoint** keyword. The position in the path where the policy-endpoint placeholder appears is resolved by SRTE internally to the Segment Routing label representing the node SID of the endpoint IP address of the policy.

This is valuable when used in conjunction with on-demand color templates since it reduces the total number of policies that must be defined. Rather than define a separate path for each color and endpoint combination, instead the user can define an on-demand color template that contains an explicit path with endpoint substitution to define policies for all endpoints of that color.

Guidelines and Limitations for SRTE Explicit-path Endpoint Substitution

SRTE Explicit-path Endpoint Substitution has the following guidelines and limitations:

- Beginning with Cisco NX-OS Release 10.1(1), SRTE Explicit-path Endpoint Substitution is supported on Cisco Nexus 9300-FX, 9300-FX2, 9300-FX3, and 9300-GX platform switches.
- If the partial path ends in the same label as the resolved endpoint label, do not append the extra (duplicated) transport label.
- SRGB must be the same on all nodes; if not, the feature may not work depending on the segment configuration of each intermediate node.
- A segment list can have only one policy-endpoint entry.

Configuring SRTE Explicit-path Endpoint Substitution

To create a policy that uses endpoint substitution, first define the path using the segment-list mode. Then associate the path with an on-demand color using its name.

Before you begin

You must ensure that the MPLS segment routing traffic engineering feature is enabled.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	segment-routing	Enters the segment routing configuration
	Example:	mode.
	<pre>switch(config)#segment-routing switch(config-sr)#</pre>	
Step 3	traffic-engineering	Enters the traffic engineering mode.
	Example:	
	<pre>switch(config-sr)# traffic-engineering switch(config-sr-te)#</pre>	
Step 4	segment-list name path	Configures an explicit segment list.
	Example:	
	<pre>switch(config-sr-te)# segment-list name path switch(config-sr-te-exp-seg-list)#</pre>	
Step 5	index 1 mpls label label-ID	Configures an MPLS label in the segment list.
	Example:	
	<pre>switch(config-sr-te-exp-seg-list)# index 1 mpls label 16201 switch(config-sr-te-exp-seg-list)#</pre>	
Step 6	index 2 policy-endpoint	Configures the policy endpoint resolution.
	Example:	
	<pre>switch(config-sr-te-exp-seg-list)# index 2 policy-endpoint switch(config-sr-te-exp-seg-list)#</pre>	
Step 7	exit	Exits the segment list mode and returns to the
	Example:	SRTE mode.
	<pre>switch(config-sr-te-exp-seg-list)# exit switch(config-sr-te)#</pre>	

	Command or Action	Purpose
Step 8	on-demand color color_num	Enters the on-demand color template mode to
	<pre>Example: switch(config-sr-te)# on-demand color 201 switch(config-sr-te-color)#</pre>	configure an on-demand color for the specified color.
Step 9	candidate-paths	Specifies the candidate paths for the SR-TE
	Example:	color policy.
	<pre>switch(config-sr-te-color)# candidate-paths</pre>	
Step 10	preference preference-number	Specifies the preference of the candidate path.
	Example:	
	<pre>switch(cfg-cndpath)# preference 100</pre>	
Step 11	explicit segment-list path	Specifies the explicit segment list.
	Example:	
	<pre>switch(cfg-pref)# explicit segment-list path</pre>	

Configuration Example for SRTE Explicit-path Endpoint Substitution

This example shows the SRTE Explicit-path Endpoint Substitution configuration:

```
switch(config)# segment-routing
switch(config-sr)# traffic-engineering
switch(config-sr-te)# segment-list name path
switch(config-sr-te-exp-seg-list)# index 1 mpls label 16201
switch(config-sr-te-exp-seg-list)# index 2 policy-endpoint
switch(config-sr-te-exp-seg-list)# exit
switch(config-sr-te)# on-demand color 201
switch(config-sr-te-color)# candidate-paths
switch(cfg-cndpath)# preference 100
switch(cfg-pref)# explicit segment-list path
```

Verifying Configuration for SRTE Explicit-path Endpoint Substitution

To display the required details about the SRTE Explicit-path Endpoint Substitution configuration, perform one of the following tasks:

Table 3: Verifying the SRTE Explicit-path Endpoint Substitution Configuration

Command	Purpose
show srte policy	Displays only the authorized policies. Note If the endpoint label is resolved and the first hop is reachable, the state is displayed as UP. If the endpoint label is not resolved or the first hop is not reachable, the state is displayed as DOWN.
show srte policy [all]	Displays the list of all policies available in the SR-TE. Note If the endpoint label is resolved and the first hop is reachable, the state is displayed as UP. If the endpoint label is not resolved or the first hop is not reachable, the state is displayed as DOWN.
show srte policy [detail]	Displays the detailed view of all the requested policies. Note If the endpoint label is resolved and the first hop is reachable, the state is displayed as UP. If the endpoint label is not resolved or the first hop is not reachable, the state is displayed as DOWN.
show srte policy <name></name>	Filters the SR-TE policy with the name and displays the list of all policies available with that name in the SR-TE. Note This command has the autocomplete feature for the policy-name. To use this feature, add a question mark or press TAB.
<pre>show srte policy color <color> endpoint <endpoint></endpoint></color></pre>	Displays the SR-TE policy for the color and endpoint. Note This command has the autocomplete feature for color and endpoint. To use this feature, add a question mark or press TAB.
show srte policy fh	Displays the state of the existing first hop and policy endpoints.

Configuring SRTE Over Default VRF

About SRTE Over Default VRF

The SRTE Over Default VRF feature allows you to incorporate segment routing traffic engineering to achieve the traffic steering benefits in your network. The SRTE provides increased scalability while using BGP for routing in large-scale data centers (DC).

The SRTE Over Default VRF feature uses the route color that exists as an extended community attribute and is represented by a number as the base for traffic steering. Based on the color, plane separation is achieved, and an SR policy is created to carry the traffic. Furthermore, based on the color, the DC is divided into different planes. The applications are configured to use each plane to only route through a specific plane and steer traffic to appropriate destinations.

Plane separation has the following advantages:

- One flow does not affect the other flow.
- · Large and small flows are separated into different planes.
- Fault isolation for better debuggability: Fault in one plane does not affect the other planes. For example, if a network fault occurs in one plane, only the applications in that plane are affected, but the applications in the rest of the planes are not impacted. Additionally, the fault can be isolated and troubleshooted in isolation.

The following example explains the SRTE Over Default VRF feature with an illustration.

Figure 6: SRTE Over Default VRF Example



- For BGP, node A is the ingress router and node D is the egress router. D is also the next-hop.
- For SRTE, node A is the SRTE headend, node D is the endpoint for the policy.
- Route prefix 1 is configured to use the blue plane, and route 2 is configured to use the red plane.

The blue traffic is appended with instructions to steer the traffic through node B and node C, and the red traffic is appended with instruction to steer traffic through node E and node F. In summary, the traffic is handled based on the color of the advertisement, that is, the prefix that was advertised earlier.

Guidelines and Limitations for Configuring SRTE Over Default VRF

- Beginning with Cisco NX-OS Release 10.1(1), segment routing traffic engineering is supported over default VRF on Cisco Nexus 9300-FX3, N9K-C9316D-GX, N9K-C93180YC-FX, N9K-C93240YC-FX2, and N9K-C9364C platform switches. The limitations for this SR-TE feature are as follows:
 - UnderLay IPv6 is not supported. SRv6 is the alternate.

- PCE using BGP underlay is not supported, due to PCE's shortcoming on BGP only fabric.
- OSPF-SRTE with PCE is not supported, due to NXOS' inability to advertise LSA in BGP-LS.
- Supports total SRTE policy scale of 1000, BGP Default VRF(v4) of 130K v4, and underlay SR prefixes of 1000.
- Beginning with Cisco NX-OS Release 10.2(3)F, the option of color-only (CO) bits is added in route map. If the value of the CO bits change for a given prefix that is using an SRTE policy, BGP will delete the old policy and add a new policy. This feature is supported on Cisco Nexus 9300-EX, 9300-FX, 9300-FX2, 9300-GX, and 9300-GX2 platform switches./

Configuration Process: SRTE Over Default VRF

The configuration process is as follows:

- 1. Set next-hop unchanged: The next-hop is used to calculate the SR policy at the ingress node. The next-hop in the SR domain on a prefix must be preserved as the prefix is advertised upstream. Hence, next-hop unchanged in needed on all upstream routers in the case for hop-by-hop ebgp.
- 2. Set extended community color at the egress node, ingress node, network/redistribute, or default-originate.
- 3. The ingress node, on receiving a color-extended community, matches it to an SR policy.
- **4.** The endpoint for the SR policy is derived from the next-hop of the prefix and color in the color-extended community.

This section includes the following topics on configuring SRTE over default VRF:

Configuring Next-hop Unchanged

To configure next-hop unchanged on the intermediate (spine) nodes for default VRF overlay, to ensure the next-hop is not changed, perform the following steps:

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map map-name	Creates a route map or enters route-map
	Example:	configuration mode for an existing route map.
	<pre>switch(config)# route-map ABC switch(config-route-map)</pre>	
Step 3	[no] set ip next-hop unchanged	Sets next-hop unchanged.
	Example:	

	Command or Action	Purpose
	<pre>switch(config-route-map)# set ip next-hop unchanged switch(config-route-map)#</pre>	
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	[no] router bgp autonomous-system-number	Enables BGP and assigns the AS number to the
	Example:	local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of
	<pre>switch(config)# router bgpl switch(config-router)#</pre>	a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	neighbor ip-address	Adds an entry to the BGP or multiprotocol BGP
	Example:	neighbor table. The ip-address argument specifies the IP address of the neighbor in dot
	<pre>switch(config-router)# neighbor 200,165,201,1</pre>	decimal notation.
	<pre>switch(config-router-neighbor)#</pre>	
Step 7	address-family ipv4 unicast	Enters router address-family configuration mode
	Example:	for the IPv4 address family type.
	<pre>switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#</pre>	
Step 8	route-map map-name out	Applies the configured BGP policy to outgoing
	Example:	routes.
	<pre>switch(config-router-neighbor-af)# route-map ABC out switch(config-router-neighbor-af)#</pre>	

Configuring Extended Community Color

This section includes the following topics:

Configuring Extended Community Color at the Egress Node

To configure extended community color at the egress node when the prefix is announced by the egress node, perform the following steps:

Procedure

I

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
_	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map map-name	Creates a route map or enters route-map
	Example:	configuration mode for an existing route map.
_	<pre>switch(config)# route-map ABC switch(config-route-map)</pre>	
Step 3	set extcommunity color <i>color-num</i> [co-flag <i>co-flag</i>]	Sets BGP extcommunity attribute for color extended community.
	Example:	co-flag: Use the color-only flag to control
	<pre>switch(config-route-map)# set extcommunity color 20 [co-flag 00] switch(config-route-map)# for the exact 00.</pre>	whether traffic may be steered into an SR Policy based on color only, if no policy can be found for the exact color and endpoint. The default is 00.
		Note Select the co-flag 00 to specify the default Automated Steering function based on color and nexthop. When the co-flag is 00 or set to default, the binding sid of the policy with the requested color and endpoint is used for routing.
		Select the co-flag 01 to steer traffic based on color only. When the co-flag is set to 01, and if the policy with requested color and endpoint exists, the binding sid of the policy is used for routing. If the policy does not exist, but the null endpoint policy with the same color exists, then the binding sid of the null endpoint policy is used for routing.
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	[no] router bgp autonomous-system-number	Enables BGP and assigns the AS number to the
	Example:	local BGP speaker. The AS number can be a
	<pre>switch(config)# router bgpl switch(config-router)#</pre>	a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.

	Command or Action	Purpose
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	neighbor ip-address	Adds an entry to the BGP or multiprotocol BGP
	Example:	neighbor table. The ip-address argument specifies the IP address of the neighbor in dotted
switch (config-router) # neighbor 209.165.201.1 switch (config-router-neighbor) #	decimal notation.	
Step 7	address-family ipv4 unicast	Enters router address-family configuration mode
Example: for the IF	for the IPv4 address family type.	
	<pre>switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#</pre>	
Step 8	route-map map-name out	Applies the configured BGP policy to outgoing
	Example:	routes.
	<pre>switch(config-router-neighbor-af)# route-map ABC out switch(config-router-neighbor-af)#</pre>	The map-name can be any case-sensitive, alphanumeric string up to 63 characters.

Configuring Extended Community Color at the Ingress Node

To configure extended community color at the ingress node when the prefix is announced by the ingress node, where the SRTE policy is instantiated, perform the following steps:

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map map-name	Creates a route map or enters route-map
	Example:	configuration mode for an existing route map.
	<pre>switch(config)# route-map ABC switch(config-route-map)</pre>	
Step 3	set extcommunity color <i>color-num</i> [co-flag <i>co-flag</i>]	Sets BGP extcommunity attribute for color extended community.
	Example:	co-flag: Use the color-only flag to control
	<pre>switch(config-route-map)# set extcommunity color 20 [co-flag 00] switch(config-route-map)#</pre>	whether traffic may be steered into an SR Policy based on color only, if no policy can be found for the exact color and endpoint. The default is 00.

	Command or Action	Purpose
		Note Select the co-flag 00 to specify the default Automated Steering function based on color and nexthop. When the co-flag is 00 or set to default, the binding sid of the policy with the requested color and endpoint is used for routing.
		Select the co-flag 01 to steer traffic based on color only. When the co-flag is set to 01, and if the policy with requested color and endpoint exists, the binding sid of the policy is used for routing. If the policy does not exist, but the null endpoint policy with the same color exists, then the binding sid of the null endpoint policy is used for routing.
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	[no] router bgp autonomous-system-number	Enables BGP and assigns the AS number to the
	<pre>Example: switch(config)# router bgpl switch(config-router)#</pre>	16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	neighbor ip-address	Adds an entry to the BGP or multiprotocol BGP
	<pre>Example: switch(config-router)# neighbor</pre>	specifies the IP address of the neighbor in dotted decimal notation.
	209.165.201.1 switch(config-router-neighbor)#	
Step 7	address-family ipv4 unicast	Enters router address-family configuration mode
	Example:	for the IPv4 address family type.
	<pre>switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#</pre>	
Step 8	route-map map-name in	Applies the configured BGP policy to incoming
	Example:	routes.
	<pre>switch(config-router-neighbor-af)# route-map ABC in switch(config-router-neighbor-af)#</pre>	The map-name can be any case-sensitive, alphanumeric string up to 63 characters.

Configuring Extended Community Color for Network/Redistribute Command at the Egress Node

To configure extended community color for the network/redistribute command at the egress node when the prefix is announced by the egress node, perform the following steps:

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	<pre>Example: switch# configure terminal switch(config)#</pre>	
Step 2	<pre>route-map map-name Example: switch(config)# route-map ABC switch(config-route-map)</pre>	Creates a route map or enters route-map configuration mode for an existing route map.
Step 3	set extcommunity color <i>color-num</i> [co-flag <i>co-flag</i>]	Sets BGP extcommunity attribute for color extended community.
	<pre>Example: switch(config-route-map)# set extcommunity color 20 [co-flag 00] switch(config-route-map)#</pre>	co-flag: Use the color-only flag to control whether traffic may be steered into an SR Policy based on color only, if no policy can be found for the exact color and endpoint. The default is 00.
		Note Select the co-flag 00 to specify the default Automated Steering function based on color and nexthop. When the co-flag is 00 or set to default, the binding sid of the policy with the requested color and endpoint is used for routing.
		Select the co-flag 01 to steer traffic based on color only. When the co-flag is set to 01, and if the policy with requested color and endpoint exists, the binding sid of the policy is used for routing. If the policy does not exist, but the null endpoint policy with the same color exists, then the binding sid of the null endpoint policy is used for routing.
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	[no] router bgp autonomous-system-number Example:	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a

	Command or Action	Purpose
	<pre>switch(config)# router bgp1 switch(config-router)#</pre>	16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	address-family ipv4 unicast	Specifies the IPv4 address family for the VRF
	Example:	instance and enters the address family
<pre>switch(config-router)# address-family ipv4 unicast switch(config-router-af)#</pre>	comgutation mode.	
Step 7	redistribute static route-map map-name out	Redistributes static routes into BGP. The
	Example:	map-name can be any case-sensitive,
	<pre>switch(config-router-af)# redistribute static route-map ABC switch(config-router-af)#</pre>	aphanumere string up to 05 characters.
Step 8	network ip-prefix [route-map map-name]	Specifies a network as local to this autonomous
	Example:	system and adds it to the BGP routing table.
	<pre>switch(config-router-af)# network 1.1.1.1/32 route-map ABC switch(config-router-af-network)#</pre>	

Configuring Extended Community Color for Default-Originate at the Egress Node

To configure extended community color for default-originate at the egress node when the default prefix is announced by the egress node, perform the following steps:

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	route-map map-name	Creates a route map or enters route-map
	Example:	configuration mode for an existing route map.
	<pre>switch(config)# route-map ABC switch(config-route-map)</pre>	The map-name can be any case-sensitive, alphanumeric string up to 63 characters.
Step 3	set extcommunity color <i>color-num</i> [co-flag <i>co-flag</i>]	Sets BGP extcommunity attribute for color extended community.
	Example:	co-flag: Use the color-only flag to control whether traffic may be steered into an SR Policy

	Command or Action	Purpose
	<pre>switch(config-route-map)# set extcommunity color 20 [co-flag 00]</pre>	based on color only, if no policy can be found for the exact color and endpoint. The default is 00.
		Note Select the co-flag 00 to specify the default Automated Steering function based on color and nexthop. When the co-flag is 00 or set to default, the binding sid of the policy with the requested color and endpoint is used for routing.
		Select the co-flag 01 to steer traffic based on color only. When the co-flag is set to 01, and if the policy with requested color and endpoint exists, the binding sid of the policy is used for routing. If the policy does not exist, but the null endpoint policy with the same color exists, then the binding sid of the null endpoint policy is used for routing.
Step 4	exit	Exits route-map configuration mode.
	Example:	
	<pre>switch(config-route-map)# exit switch(config)#</pre>	
Step 5	<pre>[no] router bgp autonomous-system-number Example: switch(config) # router bgp1 switch(config-router) #</pre>	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 6	neighbor ip-address	Adds an entry to the BGP or multiprotocol BG
	Example:	neighbor table. The ip-address argument specifies the IP address of the neighbor in dotted
<pre>switch(config-router)# ne 209.165.201.1 switch(config-router-neig)</pre>	<pre>switch(config-router)# neighbor 209.165.201.1 switch(config-router-neighbor)#</pre>	decimal notation.
Step 7	address-family ipv4 unicast	Enters router address-family configuration mode
	Example:	for the IPv4 address family type.
	<pre>switch(config-router-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#</pre>	
Step 8	default-originate [route-map map-name]	Generates a default route to the BGP peer.
	Example:	

Command or Action	Purpose
<pre>switch(config-router-neighbor-af)# default-originate route-map ABC switch(config-router-neighbor-af)#</pre>	The map-name can be any case-sensitive, alphanumeric string up to 63 characters.

Configuring BGP for Ingress Peer (SRTE Headend)

To configure BGP for the ingress peer (SRTE headend), perform the following steps.

Procedure

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[no] feature bgp	Enables BGP.
	Example:	Use the no form of this command to disable
	<pre>switch(config)# feature bgp switch(config)</pre>	this feature.
Step 3	[no] router bgp autonomous-system-number	Enables BGP and assigns the AS number to
	Example:	the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form
	<pre>switch(config)# router bgp 64496 switch(config-router)#</pre>	of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 4	address-family ipv4 unicast	Enters global address family configuration
	Example:	mode for the IPv4 address family.
	<pre>switch(config-router)# address-family</pre>	
	switch(config-router-af)#	
Step 5	neighbor ip-address	Configures the IPv4 address for a remote BGP
	Example:	peer. The ip-address format is x.x.x.x.
	<pre>switch(config-router-af)# neighbor</pre>	
	<pre>switch(config-router-af-neighbor)#</pre>	
Step 6	remote-as as-number	Configures the AS number for a remote BGP
	Example:	peer.
	<pre>switch(config-router-af-neighbor)# remote-as 64497</pre>	

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	Command or Action	Purpose
Step 7	<pre>update-source interface number Example: switch(config-router-af-neighbor)# update-source loopback 300</pre>	Specifies and updates the source of the BGP session.
Step 8	<pre>ebgp-multihop ttl-value Example: switch(config-router-af-neighbor)# ebgp-multihop 5</pre>	Configures the eBGP TTL value for eBGP multihop. The range is from 2 to 255. You must manually reset the BGP sessions after using this command.
Step 9	<pre>exit Example: switch(config-router-af-neighbor)# exit</pre>	Exits the neighbor configuration mode.
Step 10	<pre>address-family ipv4 unicast Example: switch(config-router)# address-family ipv4 unicast switch(config-router-af)#</pre>	Enters global address family configuration mode for the IPv4 address family.
Step 11	<pre>route-map map-name in Example: switch(config-router-af)# route-map color 401 in</pre>	Specifies the route map for the SRTE ingress peer. The map-name can be any case-sensitive, alphanumeric string up to 63 characters. Note Only one extended community color can be applied to an NLRI, so any route-policy/route-map applied overrides the previous extended community color, if it exists.

Configuring BGP for Egress Peer (SRTE Endpoint)

To configure BGP for the egress peer (SRTE endpoint), perform the following steps.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[no] feature bgp	Enables BGP.
	Example:	

	Command or Action	Purpose
	<pre>switch(config)# feature bgp switch(config)</pre>	Use the no form of this command to disable this feature.
Step 3	<pre>[no] router bgp autonomous-system-number Example: switch(config) # router bgp 64496 switch(config-router) #</pre>	Enables BGP and assigns the AS number to the local BGP speaker. The AS number can be a 16-bit integer or a 32-bit integer in the form of a higher 16-bit decimal number and a lower 16-bit decimal number in xx.xx format.
		Use the no option with this command to remove the BGP process and the associated configuration.
Step 4	neighbor ip-address	Configures the IPv4 address for a remote BGP
	Example:	peer. The ip-address format is x.x.x.x.
	<pre>switch(config-router)# neighbor 209.165.201.1 switch(config-router-neighbor)#</pre>	
Step 5	remote-as as-number	Configures the AS number for a remote BGP
	Example:	peer.
	<pre>switch(config-router-neighbor)# remote-as 64497</pre>	
Step 6	update-source interface-number	Specifies and updates the source of the BGP
	Example:	session.
	<pre>switch(config-router-neighbor)# update-source loopback 300</pre>	
Step 7	ebgp-multihop ttl-value	Configures the eBGP TTL value for eBGP
	Example:	multihop. The range is from 2 to 255. You must manually reset the BGP sessions after
	<pre>switch(config-router-neighbor)# ebgp-multihop 5</pre>	using this command.
Step 8	exit	Exits the neighbor configuration mode.
	Example:	
	<pre>switch(config-router-af-neighbor)# exit</pre>	
Step 9	address-family ipv4 unicast	Enters global address family configuration
	Example:	mode for the IPv4 address family.
	<pre>switch(config-router)# address-family ipv4 unicast switch(config-router-af)#</pre>	
Step 10	send-community	Specifies that the BGP community attribute
	Example:	must be sent to a BGP neighbor.
	<pre>switch(config-router-af)# send-community switch(config-router-af)#</pre>	

	Command or Action	Purpose
Step 11	<pre>send-community extended Example: switch(config-router- af)#send-community extended switch(config-router-af)#</pre>	Specifies that extended communities attribute should be sent to a BGP neighbor.
Step 12	<pre>route-map map-name out Example: switch(config-router-af)# route-map color 301 out switch(config-router-af)#</pre>	Specifies the route map for the SRTE egress peer. The map-name can be any case-sensitive, alphanumeric string up to 63 characters. Note Only one extended community color can be applied to an NLRI, so any route-policy/route-map applied overrides the previous extended community color, if it exists.

Configuring SRTE for Ingress Peer (SRTE Headend)

To configure the SRTE for ingress peer (SRTE headend), perform the following steps.

	Command or Action	Purpose
Step 1	configure terminal	Enters global configuration mode.
	Example:	
	<pre>switch# configure terminal switch(config)#</pre>	
Step 2	[no] feature mpls segment-routing	Enables MPLS SRTE.
	traffic-engineering	Use the no form of this command to disable
	Example:	this feature.
	<pre>switch(config)# feature mpls segment-routing traffic-engineering switch(config)</pre>	
Step 3	segment-routing	Enters the segment routing configuration
	Example:	mode.
	<pre>switch(config)#segment-routing switch(config-sr)#</pre>	
Step 4	traffic-engineering	Enters the traffic engineering mode.
	Example:	
	<pre>switch(config-sr)# traffic-engineering switch(config-sr-te)#</pre>	

Command or Action	Purpose
segment-list name path	Configures an explicit segment list.
Example:	
<pre>switch(config-sr-te)# segment-list name</pre>	
path switch(config-sr-te-exp-seg-list)#	
index 1 mpls label label-ID	Create an MPLS label in the segment list.
Example:	
<pre>switch(config-sr-te-exp-seg-list)# index 1 mpls label 16601 switch(config-sr-te-exp-seg-list)#</pre>	
index 2 mpls label label-ID	Creates MPLS label in the segment list.
Example:	
<pre>switch(config-sr-te-exp-seg-list)# index 2 rmls_lstsl 16501</pre>	
<pre>switch(config-sr-te-exp-seg-list)#</pre>	
policy policy-name-bgp	Specifies the SRTE policy name.
Example:	
<pre>switch(config-sr-te-exp-seg-list)# policy_dciledgelebgp</pre>	
<pre>switch(config-sr-te-exp-seg-list)#</pre>	
color color-num endpoint endpoint ID	Specifies the color and endpoint for the policy
Example:	(SRTE Egress Node Loopback).
<pre>switch(config-sr-te)# color 13401 endpoint 1.0.3.1</pre>	
candidate-paths	Specifies the candidate paths for the SRTE
Example:	color policy.
<pre>switch(config-sr-te-color)# candidate-paths</pre>	
preference preference-number	Specifies the preference of the candidate path.
Example:	
<pre>switch(cfg-cndpath)# preference 100</pre>	
explicit segment-list path	Specifies the explicit segment list.
Example:	
<pre>switch(cfg-pref)# explicit segment-list path</pre>	
	<pre>Command or Action segment-list name path Example: switch (config-sr-te) # segment-list name path switch (config-sr-te-exp-seg-list) # index 1 mpls label label-ID Example: switch (config-sr-te-exp-seg-list) # index 1 mpls label label-ID Example: switch (config-sr-te-exp-seg-list) # index 2 mpls label label-ID Example: switch (config-sr-te-exp-seg-list) # index 2 mpls label label-ID Example: switch (config-sr-te-exp-seg-list) # index 2 mpls label label-ID Example: switch (config-sr-te-exp-seg-list) # policy policy-name-bgp Example: switch (config-sr-te-exp-seg-list) # color color-num endpoint endpoint ID Example: switch (config-sr-te) # color 13401 endpoint 1.0.3.1 candidate-paths Example: switch (config-sr-te-color) # candidate-paths preference preference-number Example: switch (coffig-sr-te-color) # candidate-paths preference preference-number Example: switch (cffig-sr-te-sp-seg-list) # preference preference-number Example: switch (cffig-sr-te-sp-seg-list) # preference preference-number Example: switch (cffig-sr-te-sp-seg-list) # preference preference-number Example: switch (cffig-sr-te-sp-seg-list)</pre>

Configuration Example for SRTE Over Default VRF

The following examples show the SRTE over default VRF configuration:

Configuration Example: Next-hop Unchanged

```
route-map ABC
set ip next-hop unchanged
router bgp 1
neighbor 1.2.3.4
address-family ipv4 unicast
route-map ABC out
```

Configuration Examples: Extended Community Color

This section includes the following configuration examples for extended community color:

Configuration Example: At the Egress Node

```
ip prefix-list pfx1 seq 5 permit 7.7.7.7/32
ip prefix-list pfx2 seq 5 permit 5.0.0.0/24
route-map ABC
match ip address prefix-list pfx1 pfx2
set extcommunity color 20
router bgp 1
neighbor 1.2.3.4
address-family ipv4 unicast
route-map ABC out
```

Configuration Example: At the Ingress Node

```
ip prefix-list pfx1 seq 5 permit 7.7.7.7/32
ip prefix-list pfx2 seq 5 permit 5.0.0.0/24
route-map ABC
match ip address prefix-list pfx1 pfx2
set extcommunity color 20
router bgp 1
neighbor 1.2.3.4
address-family ipv4 unicast
route-map ABC in
```

Configuration Example: For Network/Redistribute Command at the Egress Node

```
route-map ABC
set extcommunity color 20
router bgp 1
address-family ipv4 unicast
redistribute static route-map ABC
network 1.1.1.1/32 route-map ABC
```

Configuration Example: For Default-Originate at the Egress Node

```
route-map ABC
set extcommunity color 20
router bgp 1
neighbor 1.2.3.4
address-family ipv4 unicast
default-originate route-map ABC
```

Configuration Example: BGP for Ingress Peer (SRTE Headend)

```
DCI-1(config)# show running-config bgp
feature bgp
router bgp 100
  address-family ipv4 unicast
  neighbor 1.0.3.1
   remote-as 101
   update-source loopback0
   ebgp-multihop 255
   address-family ipv4 unicast
   route-map color-3401 in
```

Configuration Example: BGP for Egress Peer (SRTE Endpoint)

This example shows the SRTE Explicit-Path Endpoint Substitution configuration:

```
Edge-1(config)# show running-config bgp
feature bgp
router bgp 101
neighbor 1.0.1.1
   remote-as 100
   update-source loopback0
   ebgp-multihop 255
   address-family ipv4 unicast
      send-community
      send-community extended
   route-map color-3401 out
```

Configuration Example: Ingress Peer for SRTE (SRTE Headend)

```
DCI-1# show running-config srte
feature mpls segment-routing traffic-engineering
segment-routing
  traffic-engineering
   segment-list name dci1-edgel
    index 1 mpls label 16601
    index 2 mpls label 16501
   policy dci1-edge1-bgp
        color 13401 endpoint 1.0.3.1
        candidate-paths
        preference 30
        explicit segment-list dci1-edge1
```

Verifying Configuration for SRTE Over Default VRF

To display the appropriate details about the SRTE over default VRF configuration, perform one of the following tasks:

Command	Purpose
show running-config bgp	Displays information about the ingress peer or the SRTE headend.
show running-config bgp	Displays information about the egress peer or the SRTE endpoint.

Table 4: Verifying SRTE Over Default VRF Configuration

Command	Purpose
show running-config srte	Displays information about the SRTE policy for ingress peer.

Additional References

Related Documents

Related Topic	Document Title
BGP	Cisco Nexus 9000 Series Unicast Routing Configuration Guide