Cisco Nexus 3600 Switch NX-OS Label Switching Configuration Guide, Release 10.4(x)

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Preface

This preface includes the following sections:

Audience

This publication is for network administrators who install, configure, and maintain Cisco Nexus switches.

Document Conventions

Command descriptions use the following conventions:

Convention	Description
bold	Bold text indicates the commands and keywords that you enter literally as shown.
Italic	Italic text indicates arguments for which the user supplies the values.
[x]	Square brackets enclose an optional element (keyword or argument).
[x | y]	Square brackets enclosing keywords or arguments separated by a vertical bar indicate an optional choice.
{x | y}	Braces enclosing keywords or arguments separated by a vertical bar indicate a required choice.
[x {y | z}]	Nested set of square brackets or braces indicate optional or required choices within optional or required elements. Braces and a vertical bar within square brackets indicate a required choice within an optional element.

Convention	Description
`variable`	Indicates a variable for which you supply values, in context where italics cannot be used.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.

Examples use the following conventions:

Convention	Description
`screen font`	Terminal sessions and information the switch displays are in screen font.
`boldface screen font`	Information you must enter is in boldface screen font.
italic screen font	Arguments for which you supply values are in italic screen font.
< >	Nonprinting characters, such as passwords, are in angle brackets.
[ ]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.

Related Documentation for Cisco Nexus 3000 Series Switches

The entire Cisco Nexus 3000 Series switch documentation set is available at the following URL:

https://www.cisco.com/c/en/us/support/switches/nexus-3000-series-switches/tsd-products-support-series-home.html

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CHAPTER 1

New and Changed Information

New and Changed Information

Table 1: New and Changed Features

Feature	Description	Changed in Release	Where Documented
NA	No feature updates for this release.	10.4(1)F	NA

CHAPTER 2

Overview

Licensing Requirements

For a complete explanation of Cisco NX-OS licensing recommendations and how to obtain and apply licenses, see the *Cisco NX-OS Licensing Guide* and the *Cisco NX-OS Licensing Options Guide*.

Supported Platforms

Starting with Cisco NX-OS release 7.0(3)I7(1), use the Nexus Switch Platform Support Matrix to know from which Cisco NX-OS releases various Cisco Nexus 9000 and 3000 switches support a selected feature.

CHAPTER 3

Configuring Segment Routing

This chapter contains information on how to configure segment routing.

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 7.

Guidelines and Limitations for Segment Routing

Segment routing has the following guidelines and limitations:

- MPLS Segment Routing can be enabled on physical ethernet interfaces and port-channel bundles. It is not supported on ethernet sub-interfaces or Switchedx Virtual Interfaces (SVI).
- BGP allocates a 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 a RR, the next hop is changed for the routes that are being affected (subject to route-map filtering).
- Static MPLS, MPLS segment routing, and MPLS stripping cannot be enabled at the same time.
- 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 out-label 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.
- The BGP configuration commands **neighbor-down fib-accelerate** and **suppress-fib-pending** are not supported for MPLS prefixes.
- 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.
- When the segment routing global block (SRGB) is set to a range but the route-map label-index delta value falls outside the configured range, the allocated label is dynamically generated. For example, if the SRGB is set to a range of 16000-23999 but 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. However, beginning with Cisco NX-OS Release 10.3(2)F, proactive consistency checker will be supporting IPv4/IPv6,

ARP/ND adjacencies and MPLS routes for IPv4, IPv6, VPNv4, VPNv6, and PE/Deagg FEC types on Cisco Nexus 3600 platform switches (N3K-C36180YC-R and N3K-C3636C-R).

- Deleting the segment routing configuration removes all the related segment routing configurations.
- Layer3 VPN over Segment Routing is supported on Cisco Nexus 3600 platform switches with N3K-C3636C-R and N3K-C36180YC-R line cards.
- 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 will be 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.

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.

SUMMARY STEPS

1. **configure terminal**
2. **segment-routing**
3. **connected-prefix-sid-map**
4. **global-block** <*min*> <*max*>
5. **connected-prefix-sid-map**
6. **address-family ipv4**
7. <*prefix*>/<*masklen*> [**index**|**absolute**] <*label*>

DETAILED STEPS

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

	Command or Action	Purpose

	`switch# configure terminal`
	`switch(config)#`	

Step 2	**segment-routing**
	Example:
	`switch(config)# segment-routing`
	`switch(config-sr)# mpls`
	`switch(config-sr-mpls)#`
		Enables the MPLS segment routing functionality. The **no** form of this command disables the MPLS segment routing feature.

Step 3	**connected-prefix-sid-map**
	Example:
	`switch(config-sr-mpls)# connected-prefix-sid-map`
	`switch(config-sr-mpls)#`
		Configures the connected prefix segment identifier mappings.

Step 4	**global-block** *<min>* *<max>*
	Example:
	`switch(config-sr-mpls)# global-block  <min> <max>`
	`switch(config-sr-mpls)#`
		Specifies the global block range for the segment routing bindings.

Step 5	**connected-prefix-sid-map**
	Example:
	`switch(config-sr-mpls)# connected-prefix-sid-map`
	`switch(config-sr-mpls-conn-pfsid)#`
		Configures the connected prefix segment identifier mappings.

Step 6	**address-family ipv4** **Example:** `switch(config-sr-mpls-conn-pfsid)#address-family ipv4`	Configures the IPv4 address family.
Step 7	*<prefix>*/*<masklen>* [**index**|**absolute**] *<label>* **Example:** `switch(config-sr-mpls)# 2.1.1.5/32 absolute 201101`	The optional keywords **index** or **absolute** indicate whether the label value entered should be interpreted as an index into the SRGB or as 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
13.11.2.0/24       713   Indx 1     Y
30.7.7.7/32        730   Indx 1     Y
59.3.24.0/30       759   Indx 1     Y
150.101.1.0/24     801   Indx 1     Y
150.101.1.1/32     802   Indx 1     Y
150.101.2.0/24     803   Indx 1     Y
1.1.1.1/32         16013 Abs  1     Y
```

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.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type slot/port*
3. [**no**] **mpls ip forwarding**
4. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**interface** *type slot/port*
	Example:
	`switch(config)# interface ethernet 2/2`
	`switch(config-if)#`
		Enters the interface configuration mode for the specified interface.

Step 3	[**no**] **mpls ip forwarding** **Example:** `switch(config-if)# mpls ip forwarding`	Enables MPLS on the specified interface. The **no** form of this command disables MPLS on the specified interface.
Step 4	(Optional) **copy running-config startup-config** **Example:** `switch(config-if)# copy running-config startup-config`	Copies the running configuration to the startup configuration.

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.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **segment-routing**
3. [**no**] **global-block** *beginning-label ending-label*
4. (Optional) **show mpls label range**
5. **show segment-routing**
6. **show segment-routing mpls**
7. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **segment-routing**
	Example:
	`switch(config)# segment-routing`
	`switch(config-sr)# mpls`
		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	[**no**] **global-block** *beginning-label ending-label* **Example:** `switch(config-sr-mpls)# global-block 16000 471804`	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.

	Command or Action	Purpose
		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	(Optional) **show mpls label range** **Example:** `switch(config-sr-mpls)# show mpls label range`	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** **Example:** `switch(config-sr-mpls)# show segment-routing mpls`	Displays the configured SRGB.
Step 7	(Optional) **copy running-config startup-config** **Example:** `switch(config-sr-mpls)# copy running-config startup-config`	Copies the running configuration to the startup configuration.

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 20.20.20.20/32 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
  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 2.2.2.2/32
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 0.0.0.0/0 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 1.1.1.9%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            | Next-hop                                | Interface              | Labels
          | Partial Install
--------------+-------------------------------+-----------------+------------+-------------
0.0.0.0/32           Drop                                       Null0
127.0.0.0/8          Drop                                       Null0
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
                     37.2.53.4                                  Ethernet1/53/2         PUSH
  29002 492529
```

```
                   37.2.54.4                                 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 l2vpn 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

Neighbor        V    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)
1.1.1.9         4    11    4637    1836 17370542    0    0 23:01:40 476
1.1.1.10        4    11       0       0        0    0    0 23:01:53 Shut (Admin)
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.

```
show bgp l2vpn 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]:[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]:[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]:[0]:[24]:[41.11.2.0]:[0.0.0.0]/224
  AS-Path: 11 , path sourced external to AS
    1.1.1.9 (metric 0) from 1.1.1.9 (14.1.4.1)
```

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.

SUMMARY STEPS

1. **configure terminal**
2. **router isis** *instance-tag*
3. **net** *network-entity-title*
4. **address-family** *ipv4* **unicast**
5. **segment-routing mpls**

DETAILED STEPS

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

	Command or Action	Purpose
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** *ipv4* **unicast**	Enters address family configuration mode.
Step 5	**segment-routing mpls**	Configures segment routing with IS-IS protocol. **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.

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.

Note 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.

SUMMARY STEPS

1. **configure terminal**
2. [**no**]**router ospf** *process*
3. **segment-routing**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**]**router ospf** *process* **Example:**	Enables the OSPF mode.

	Command or Action	Purpose
	`switch(config)# router ospf test`	
Step 3	**segment-routing** **Example:** `switch(config-router)# segment-routing mpls`	Configures the segment routing functionality under OSPF.

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.

SUMMARY STEPS

1. **router ospf process**
2. **area** <*area id*> **segment-routing** [**mpls** | **disable**]
3. [**no**]**area** <*area id*> **segment-routing** [**mpls** | **disable**]
4. **show ip ospf** *process* **segment-routing**

DETAILED STEPS

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

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.

SUMMARY STEPS

1. **configure terminal**
2. [**no**]**router ospf** *process*
3. **segment-routing**
4. **interface loopback** *interface_number*
5. **ip address 1.1.1.1/32**
6. **ip router ospf 1 area 0**
7. **segment-routing**
8. **connected-prefix-sid-map**
9. **address-family ipv4**
10. **1.1.1.1/32 index 10**
11. **exit**

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure terminal** **Example:** `switch# configure terminal`	Enters global configuration mode.
Step 2	[**no**]**router ospf** *process* **Example:** `switch(config)# router ospf test`	Configures OSPF.

Step 3	**segment-routing**
	Example:
	`switch(config-router)# segment-routing`
	`switch(config-sr)#mpls`
	`switch(config-sr-mpls)#`
		Configures the segment routing functionality under OSPF.

Step 4	**interface loopback** *interface_number* **Example:** `switch(config-sr-mpls)# Interface loopback 0`	Specifies the interface where OSPF is enabled.
Step 5	**ip address 1.1.1.1/32** **Example:** `switch(config-sr-mpls)# ip address 1.1.1.1/32`	Specifies the IP address configured on the ospf interface.
Step 6	**ip router ospf 1 area 0** **Example:** `switch(config-sr-mpls)# ip router ospf 1 area 0`	Specifies the OSPF enabled on the interface in area.

	Command or Action	Purpose

Step 7	**segment-routing**
	Example:
	`switch(config-router)#segment-routing`
	`(config-sr)#mpls`
		Configures prefix-sid mapping under SR module.

Step 8	**connected-prefix-sid-map**
	Example:
	`switch(config-sr-mpls)# connected-prefix-sid-map`
	`switch(config-sr-mpls-conn-pfxsid)#`
		Configures the prefix SID mapping under the segment routing module.

Step 9	**address-family ipv4**
	Example:
	`switch(config-sr-mpls-conn-pfxsid)# address-family ipv4`
	`switch(config-sr-mpls-conn-pfxsid-af)#`
		Specifies the IPv4 address family configured on the OSPF interface.

Step 10	**1.1.1.1/32 index 10** **Example:** `switch(config-sr-mpls-conn-af)# 1.1.1.1/32 index 10`	Associates SID 10 with the address 1.1.1.1/32.
Step 11	**exit** **Example:** `switch(config-sr-mpls-conn-af)# exit`	Exits segment routing mode and returns to the configuration terminal mode.

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.

SUMMARY STEPS

1. **configure terminal**
2. **interface loopback3**
3. **ip ospf prefix-attributes n-flag-clear**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

	Command or Action	Purpose
Step 2	**interface loopback3** **Example:** `switch(config)# interface loopback3`	Specifies the interface loopback.
Step 3	**ip ospf prefix-attributes n-flag-clear** **Example:** `switch#(config-if)# ip ospf prefix-attributes n-flag-clear`	Clears the prefix N-flag.

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 Prefix SID Using BGP

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 3600 Series NX-OS Unicast Routing Configuration Guide.)

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.

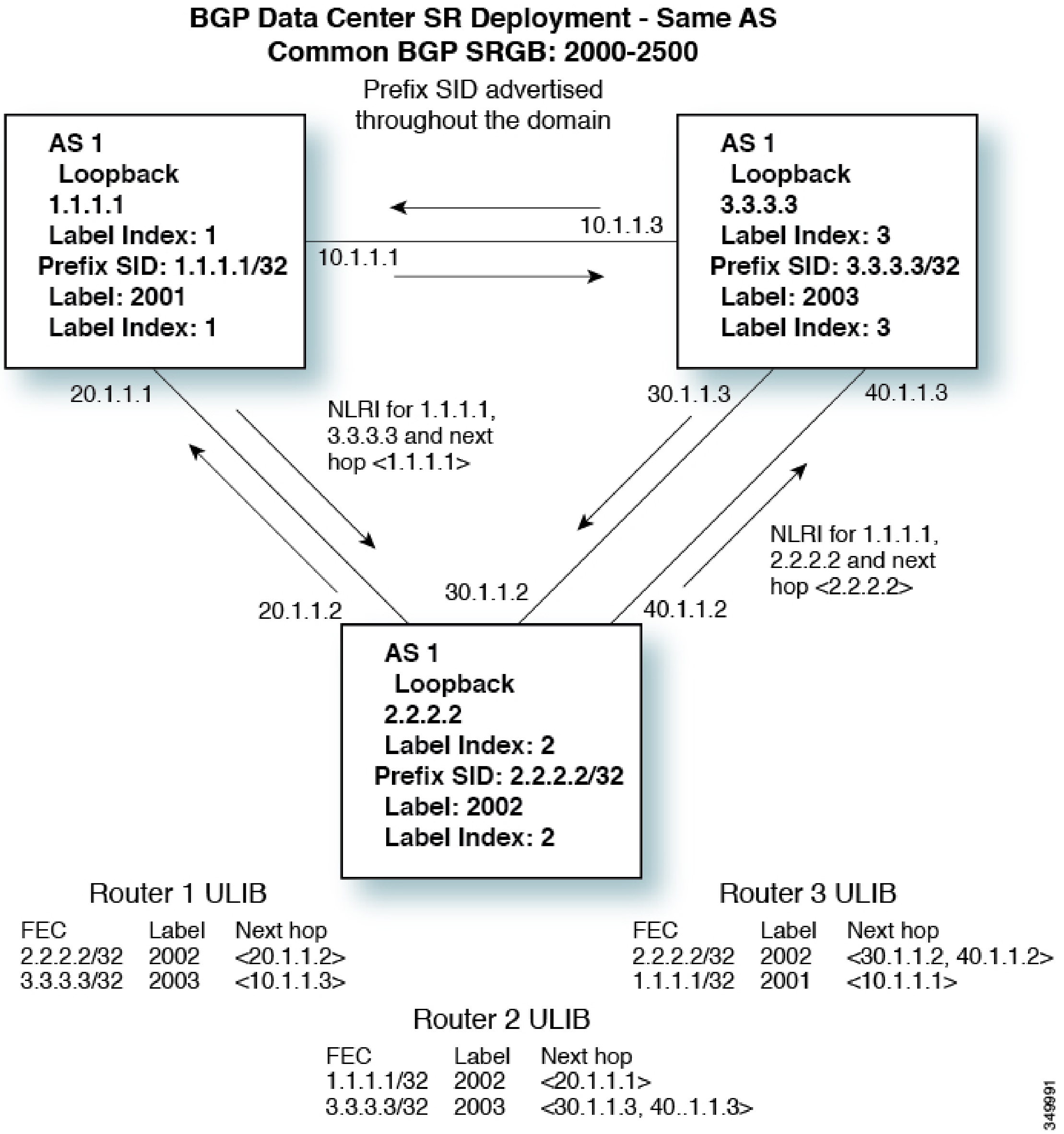
BGP Prefix SID

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.

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 1: BGP Prefix SID Simple Example



BGP Data Center SR Deployment - Same AS
Common BGP SRGB: 2000-2500
Prefix SID advertised throughout the domain
AS 1 Loopback 1.1.1.1 Label Index: 1 Prefix SID: 1.1.1.1/32 Label: 2001 Label Index: 1
AS 1 Loopback 3.3.3.3 Label Index: 3 Prefix SID: 3.3.3.3/32 Label: 2003 Label Index: 3
AS 1 Loopback 2.2.2.2 Label Index: 2 Prefix SID: 2.2.2.2/32 Label: 2002 Label Index: 2
10.1.1.3
10.1.1.1
20.1.1.1
NLRI for 1.1.1.1, 3.3.3.3 and next hop <1.1.1.1>
30.1.1.3
40.1.1.3
NLRI for 1.1.1.1, 2.2.2.2 and next hop <2.2.2.2>
20.1.1.2
30.1.1.2
40.1.1.2
349991

Router 1 ULIB

FEC	Label	Next hop
2.2.2.2/32	2002	<20.1.1.2>
3.3.3.3/32	2003	<10.1.1.3>

Router 3 ULIB

FEC	Label	Next hop
2.2.2.2/32	2002	<30.1.1.2, 40.1.1.2>
1.1.1.1/32	2001	<10.1.1.1>

Router 2 ULIB

FEC	Label	Next hop
1.1.1.1/32	2002	<20.1.1.1>
3.3.3.3/32	2003	<30.1.1.3, 40..1.1.3>

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.

Configuring the Label Index

SUMMARY STEPS

1. **configure terminal**
2. **route-map** *map-name*
3. [**no**] **set label-index** *index*
4. **exit**
5. **router bgp** *autonomous-system-number*
6. **address-family ipv4 unicast**
7. **network** *ip-prefix* [**route-map** *map-name*]
8. (Optional) **show route-map** [*map-name*]
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**route-map** *map-name*
	Example:
	`switch(config)# route-map SRmap`
	`switch(config-route-map)#`
		Creates a route map or enters route-map configuration mode for an existing route map.

Step 3	[**no**] **set label-index** *index* **Example:** `switch(config-route-map)# set label-index 10`	Sets the label index for routes that match the **network** command. The range is from 0 to 471788. By default, a label index is not added to the route.

Step 4	**exit**
	Example:
	`switch(config-route-map)# exit`
	`switch(config)#`
		Exits route-map configuration mode.

	Command or Action	Purpose

Step 5	**router bgp** *autonomous-system-number*
	Example:
	`switch(config)# router bgp 64496`
	`switch(config-router)#`
		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.

Step 6	Required: **address-family ipv4 unicast**
	Example:
	`switch(config-router)# address-family ipv4 unicast`
	`switch(config-router-af)#`
		Enters global address family configuration mode for the IPv4 address family.

Step 7	**network** *ip-prefix* [**route-map** *map-name*] **Example:** `switch(config-router-af)# network 10.10.10.10/32 route-map SRmap`	Specifies a network as local to this autonomous system and adds it to the BGP routing table.
Step 8	(Optional) **show route-map** [*map-name*] **Example:** `switch(config-router-af)# show route-map`	Displays information about route maps, including the label index.
Step 9	(Optional) **copy running-config startup-config** **Example:** `switch(config-router-af)# copy running-config startup-config`	Copies the running configuration to the startup configuration.

Configuring the MPLS Label Allocation

You can configure MPLS label allocation for the IPv4 unicast address family.

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.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **router bgp** *autonomous-system-number*
3. **address-family ipv4 unicast**
4. [**no**] **allocate-label** {**all** | **route-map** *route-map-name*}
5. **exit**
6. **neighbor** *ipv4-address* **remote-as** *autonomous-system-number*
7. **address-family ipv4 labeled-unicast**
8. (Optional) **show bgp ipv4 labeled-unicast** *prefix*
9. (Optional) **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **router bgp** *autonomous-system-number*
	Example:
	`switch(config)# router bgp 64496`
	`switch(config-router)#`
		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 ipv4 unicast**
	Example:
	`switch(config-router)# address-family ipv4 unicast`
	`switch(config-router-af)#`
		Enters global address family configuration mode for the IPv4 address family.

Step 4	[**no**] **allocate-label** {**all** | **route-map** *route-map-name*}
	Example:
	`switch(config-router-af)# allocate-label route-map map1`
		Configures local label allocation for routes matching the specified route map or for all routes advertised in this address family.

Step 5	Required: **exit**
	Example:
	`switch(config-router-af)# exit`
	`switch(config-router)#`
		Exits global address family configuration mode.

Step 6	**neighbor** *ipv4-address* **remote-as** *autonomous-system-number*
	Example:
	`switch(config-router)# neighbor 10.1.1.1 remote-as 64497`
	`switch(config-router-neighbor)#`
		Configures the IPv4 address and AS number for a remote BGP peer.

Step 7	**address-family ipv4 labeled-unicast**
	Example:
	`switch(config-router-neighbor)# address-family ipv4 labeled-unicast`
	`switch(config-router-neighbor-af)#`
		Advertises the labeled IPv4 unicast routes as specified in RFC 3107.

Step 8	(Optional) **show bgp ipv4 labeled-unicast** *prefix* **Example:** `switch(config-router-neighbor-af)# show bgp ipv4 labeled-unicast 10.10.10.10/32`	Displays the advertised label index and the selected local label for the specified IPv4 prefix.

	Command or Action	Purpose
Step 9	(Optional) **copy running-config startup-config** **Example:** `switch(config-router-neighbor-af)# copy running-config startup-config`	Copies the running configuration to the startup configuration.

Configuration Example for BGP Prefix SID

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 20.20.20.20/32 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

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
  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 2.2.2.2/32
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
```

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.

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** <*bgp autonomous number*>
3. [**no**] **address-family link-state**

4. **neighbor** <*IP address*>
5. [**no**] **address-family link-state**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**router bgp** <*bgp autonomous number*>	Specifies the autonomous router BGP number.

Step 3	[**no**] **address-family link-state**
	Example:
	`switch(config)# router bgp 64497`
	`switch (config-router af)# address-family link-state`
		Enters address-family interface configuration mode.
		Note This command can also be configured in neighbor address-family configuration mode.

Step 4	**neighbor** <*IP address*>	Configures the IP address for the neighbor.

Step 5	[**no**] **address-family link-state**
	Example:
	`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`
		Enters address-family interface configuration mode.
		Note This command can also be configured in neighbor address-family configuration mode.

Verifying the Segment Routing Configuration

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

Command	Purpose
show bgp ipv4 labeled-unicast *prefix*	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.
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.

Command	Purpose
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*>	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.
show srte policy color <*color*> **endpoint** <*endpoint*>	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
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.

Command	Purpose
show ip ospf *process* **segment-routing global block**	Displays the segment routing global block information.

Additional References

Related Documents

Related Topic	Document Title
BGP	*Cisco Nexus 3600 Series Unicast Routing Configuration Guide*

CHAPTER 4

Configuring MPLS Layer 3 VPNs

This chapter describes how to configure Multiprotocol Label Switching (MPLS) Layer 3 virtual private networks (VPNs) on Cisco Nexus 3600 Series Switches.

Information About MPLS Layer 3 VPNs

An MPLS Layer 3 VPN consists of a set of sites that are interconnected by an MPLS provider core network. At each customer site, one or more customer edge (CE) routers or Layer 2 switches attach to one or more provider edge (PE) routers. This section includes the following topics:

- MPLS Layer 3 VPN Definition
- How an MPLS Layer 3 VPN Works
- Components of MPLS Layer 3 VPNs
- Hub-and-Spoke Topology
- OSPF Sham-Link Support for MPLS VPN

MPLS Layer 3 VPN Definition

MPLS-based Layer 3 VPNs are based on a peer model that enables the provider and the customer to exchange Layer 3 routing information. The provider relays the data between the customer sites without direct customer involvement.

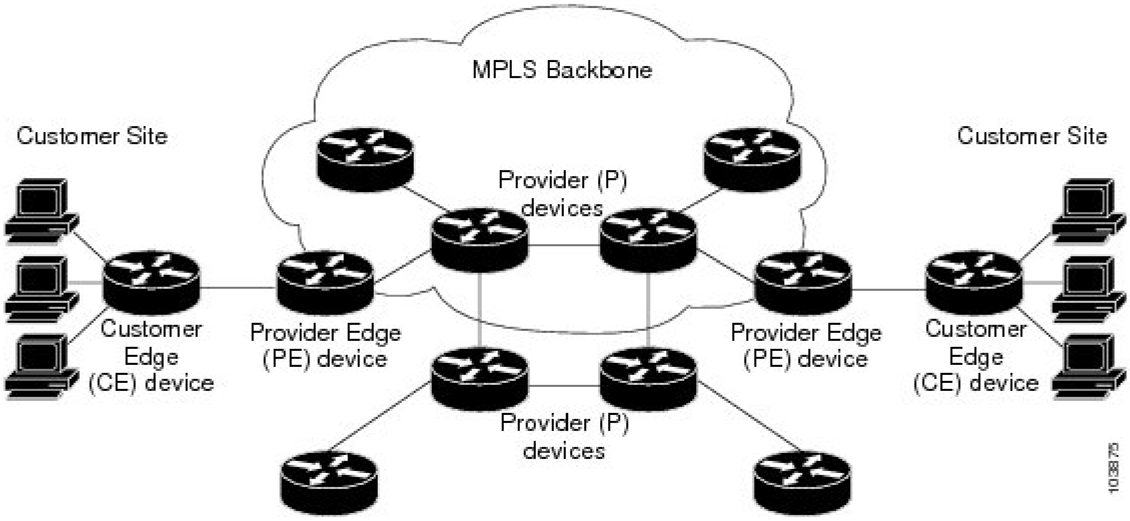
When you add a new site to an MPLS Layer 3 VPN, you must update the provider edge router that provides services to the customer site.

MPLS Layer 3 VPNs include the following components:

- Provider (P) router—A router in the core of the provider network. P routers run MPLS switching and do not attach VPN labels (an MPLS label in each route assigned by the PE router) to routed packets. P routers forward packets based on the Label Distribution Protocol (LDP).

- Provider edge (PE) router—A router that attaches the VPN label to incoming packets that are based on the interface or subinterface on which they are received. A PE router attaches directly to a CE router.
- Customer edge (CE) router—An edge router on the network of the provider that connects to the PE router on the network. A CE router must interface with a PE router.

Figure 2: Basic MPLS Layer 3 VPN Terminology


MPLS Backbone
Customer Site
Customer Site
Provider (P) devices
Customer Edge (CE) device
Provider Edge (PE) device
Provider Edge (PE) device
Customer Edge (CE) device
Provider (P) devices
103875

How an MPLS Layer 3 VPN Works

MPLS Layer 3 VPN functionality is enabled at the edge of an MPLS network. The PE router performs the following tasks:

- Exchanges routing updates with the CE router
- Translates the CE routing information into VPN routes
- Exchanges Layer 3 VPN routes with other PE routers through the Multiprotocol Border Gateway Protocol (MP-BGP)

Components of MPLS Layer 3 VPNs

An MPLS-based Layer 3 VPN network has three components:

1. VPN route target communities—A VPN route target community is a list of all members of a Layer 3 VPN community. You must configure the VPN route targets for each Layer 3 VPN community member.
2. Multiprotocol BGP peering of VPN community PE routers—Multiprotocol BGP propagates VRF reachability information to all members of a VPN community. You must configure Multiprotocol BGP peering in all PE routers within a VPN community.
3. MPLS forwarding—MPLS transports all traffic between all VPN community members across a VPN enterprise or service provider network.

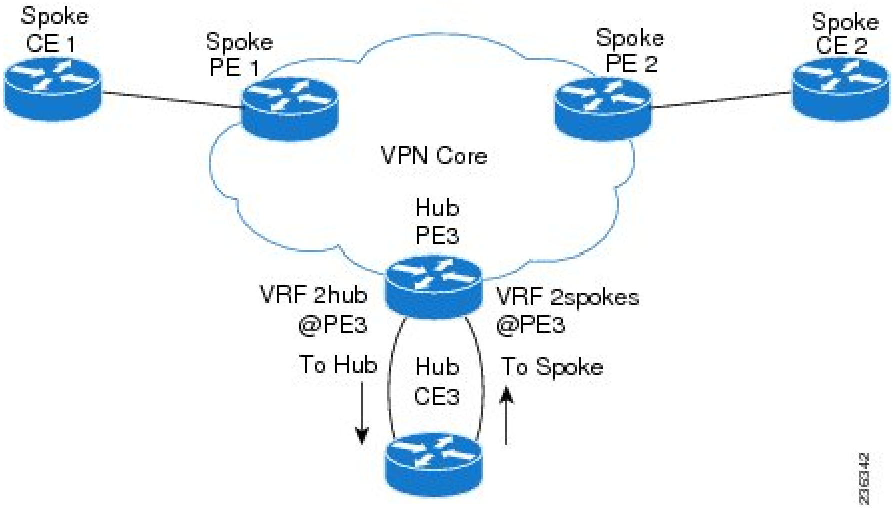
A one-to-one relationship does not necessarily exist between customer sites and VPNs. A site can be a member of multiple VPNs. However, a site can associate with only one VRF. A customer-site VRF contains all the routes that are available to the site from the VPNs of which it is a member.

Hub-and-Spoke Topology

A hub-and-spoke topology prevents local connectivity between subscribers at the spoke provider edge (PE) routers and ensures that a hub site provides subscriber connectivity. Any sites that connect to the same PE router must forward intersite traffic using the hub site. This topology ensures that the routing at the spoke sites moves from the access-side interface to the network-side interface or from the network-side interface to the access-side interface but never from the access-side interface to the access-side interface. A hub-and-spoke topology allows you to maintain access restrictions between sites.

A hub-and-spoke topology prevents situations where the PE router locally switches the spokes without passing the traffic through the hub site. This topology prevents subscribers from directly connecting to each other. A hub-and-spoke topology does not require one VRF for each spoke.

Figure 3: Hub-and-Spoke Topology



As shown in the figure, a hub-and-spoke topology is typically set up with a hub PE that is configured with two VRFs:

- VRF 2hub with a dedicated link connected to the hub customer edge (CE)
- VRF 2spokes with another dedicated link connected to the hub CE.

Interior Gateway Protocol (IGP) or external BGP (eBGP) sessions are usually set up through the hub PE-CE links. The VRF 2hub imports all the exported route targets from all the spoke PEs. The hub CE learns all routes from the spoke sites and readvertises them back to the VRF 2spoke of the hub PE. The VRF 2spoke exports all these routes to the spoke PEs.

If you use eBGP between the hub PE and hub CE, you must allow duplicate autonomous system (AS) numbers in the path which is normally prohibited. You can configure the router to allow this duplicate AS number at the neighbor of VRF 2spokes of the hub PE and also for VPN address family neighbors at all the spoke PEs. In addition, you must disable the peer AS number check at the hub CE when distributing routes to the neighbor at VRF 2spokes of the hub PE.

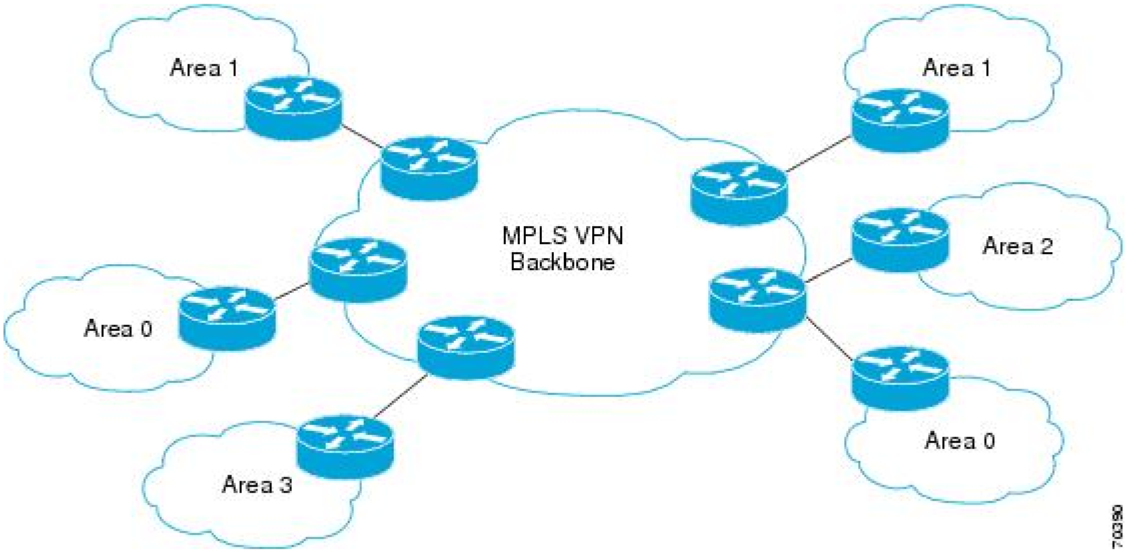
OSPF Sham-Link Support for MPLS VPN

In a Multiprotocol Label Switching (MPLS) VPN configuration, you can use the Open Shortest Path First (OSPF) protocol to connect customer edge (CE) devices to service provider edge (PE) devices in the VPN backbone. Many customers run OSPF as their intrasite routing protocol, subscribe to a VPN service, and want to exchange routing information between their sites using OSPF (during migration or on a permanent basis) over an MPLS VPN backbone.

The benefits of the OSPF sham-link support for MPLS VPN are as follows:

- Client site connection across the MPLS VPN Backbone—A sham link ensures that OSPF client sites that share a backdoor link can communicate over the MPLS VPN backbone and participate in VPN services.
- Flexible routing in an MPLS VPN configuration—In an MPLS VPN configuration, the OSPF cost tha is configured with a sham link allows you to decide if OSPF client site traffic is routed over a backdoor link or through the VPN backbone.

The figure below shows an example of how VPN client sites that run OSPF can connect over an MPLS VPN backbone.



When you use OSPF to connect PE and CE devices, all routing information learned from a VPN site is placed in the VPN routing and forwarding (VRF) instance that is associated with the incoming interface. The PE devices that attach to the VPN use the Border Gateway Protocol (BGP) to distribute VPN routes to each other. A CE device can learn the routes to other sites in the VPN by peering with its attached PE device. The MPLS VPN super backbone provides an additional level of routing hierarchy to interconnect the VPN sites that are running OSPF.

When OSPF routes are propagated over the MPLS VPN backbone, additional information about the prefix in the form of BGP extended communities (route type, domain ID extended communities) is appended to the BGP update. This community information is used by the receiving PE device to decide the type of link-state advertisement (LSA) to be generated when the BGP route is redistributed to the OSPF PE-CE process. In this way, internal OSPF routes that belong to the same VPN and are advertised over the VPN backbone are seen as interarea routes on the remote sites.

Prerequisites for MPLS Layer 3 VPNs

MPLS Layer 3 VPNs has the following prerequisites:

- Ensure that you have configured MPLS and Label Distribution Protocol (LDP) in your network. All routers in the core, including the PE routers, must be able to support MPLS forwarding.
- Ensure that you have installed the correct license for MPLS and any other features you will be using with MPLS.

Guidelines and Limitations for MPLS Layer 3 VPNs

MPLS Layer 3 VPNs have the following configuration guidelines and limitations:

- You can configure MPLS Layer 3 VPN (LDP) on Cisco Nexus 3600-R and Cisco Nexus 9504 and 9508 platform switches with the N9K-X9636C-RX, N9K-X9636C-R, N9K-X96136YC-R, and N9K-X9636Q-R line cards.
- You must enable MPLS IP forwarding on interfaces where the forwarding decisions are made based on the labels of incoming packets. If a VPN label is allocated by per prefix mode, MPLS IP forwarding must be enabled on the link between PE and CE.
- Packets with MPLS Explicit-NULL may not be parsed correctly with default line card profile.
- MPLS Layer 3 VPNs support the following CE-PE routing protocols:
-
    - BGP (IPv4 and IPv6)
    - Enhanced Interior Gateway Protocol (EIGRP) (IPv4)
    - Open Shortest Path First (OSPFv2)
    - Routing Information Protocol (RIPv2)

  Set statements in an import route map are ignored.
- The BGP minimum route advertisement interval (MRAI) value for all iBGP and eBGP sessions is zero and is not configurable.
- In a high scale setup with many BGP routes getting redistributed into EIGRP, modify the EIGRP signal timer to ensure that the EIGRP convergence time is higher than the BGP convergence time. This process allows all the BGP routes to be redistributed into EIGRP, before EIGRP signals convergence.
- When OSPF is used as a protocol between PE and CE devices, the OSPF metric is preserved when routes are advertised over the VPN backbone. The metric is used on the remote PE devices to select the correct route. Do not modify the metric value when OSPF is redistributed to BGP and when BGP is redistributed to OSPF. If you modify the metric value, routing loops might occur.

Default Settings for MPLS Layer 3 VPNs

Table 2: Default MPLS Layer 3 VPN Parameters

Parameters	Default
L3VPN feature	Disabled
L3VPN SNMP notifications	Disabled
allowas-in (for a hub-and-spoke topology)	0
disable-peer-as-check (for a hub-and-spoke topology)	Disabled

Configuring MPLS Layer 3 VPNs

Configuring the Core Network

Assessing the Needs of MPLS Layer 3 VPN Customers

You can identify the core network topology so that it can best serve MPLS Layer 3 VPN customers.

- Identify the size of the network:
    - Identify the following to determine the number of routers and ports you need:
    - How many customers do you need to support?
    - How many VPNs are needed per customer?
    - How many virtual routing and forwarding instances are there for each VPN?
- Determine which routing protocols you need in the core network.
- Determine if you need MPLS VPN high availability support.

Note MPLS VPN nonstop forwarding and graceful restart are supported on select routers and Cisco NX-OS releases. You need to make sure that graceful restart for BGP and LDP is enabled.

- Configure the routing protocols in the core network.
- Determine if you need BGP load sharing and redundant paths in the MPLS Layer 3 VPN core.

Configuring MPLS in the Core

To enable MPLS on all routers in the core, you must configure a label distribution protocol. You can use either of the following as a label distribution protocol:

- MPLS Label Distribution Protocol (LDP).

Configuring Multiprotocol BGP on the PE Routers and Route Reflectors

You can configure multiprotocol BGP connectivity on the PE routers and route reflectors.

Before you begin

Ensure that graceful restart is enabled on all routers for BGP and LDP.

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **install feature-set mpls**
4. **feature-set mpls**
5. **feature-set mpls l3vpn**
6. **router bgp** *as - number*
7. **router-id** *ip-address*
8. **neighbor** *ip-address***remote-as** *as-number*
9. **address-family { vpnv4 | vpnv6 } unicast**
10. **send-community extended**
11. **show bgp { vpnv4 | vpnv6 } unicast neighbors**
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 3	**install feature-set mpls**
	Example:
	`switch(config)# install feature-set mpls`
	`switch(config)#`
		Installs the MPLS feature set.

	Command or Action	Purpose

Step 4	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

Step 5	**feature-set mpls l3vpn**
	Example:
	`switch(config)# feature-set mpls l3vpn`
	`switch(config)#`
		Enables the MPLS Layer 3 VPN feature.

Step 6	**router bgp** *as - number* **Example:** `switch(config)# router bgp 1.1`	Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information. 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.
Step 7	**router-id** *ip-address* **Example:** `switch(config-router)# router-id 192.0.2.255`	(Optional) Configures the BGP router ID. This IP address identifies this BGP speaker. This command triggers an automatic notification and session reset for the BGP neighbor sessions. .

Step 8	**neighbor** *ip-address***remote-as** *as-number*
	Example:
	`switch(config-router)# neighbor 209.165.201.1 remote-as 1.1`
	`switch(config-router-neighbor)#`
		Adds an entry to the iBGP neighbor table. The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.

Step 9	**address-family { vpnv4 | vpnv6 } unicast**
	Example:
	`switch(config-router-neighbor)# address-family vpnv4 unicast`
	`switch(config-router-neighbor-af)#`
		Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 or VPNv6 address prefixes.

Step 10	**send-community extended** **Example:** `switch(config-router-neighbor-af)# send-community extended`	Specifies that a communities attribute should be sent to a BGP neighbor.
Step 11	**show bgp { vpnv4 | vpnv6 } unicast neighbors** **Example:** `switch(config-router-neighbor-af)# show bgp vpnv4 unicast neighbors`	(Optional) Displays information about BGP neighbors.

	Command or Action	Purpose
Step 12	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Connecting the MPLS VPN Customers

Defining VRFs on the PE Routers to Enable Customer Connectivity

You must create VRFs on the PE routers to enable customer connectivity. You configure route targets to control which IP prefixes are imported into the customer VPN site and which IP prefixes are exported to the BGP network. You can optionally use an import or export route map to provide more fine-grained control over the IP prefixes that are imported into the customer VPN site or exported out of the VPN site. You can use a route map to filter routes that are eligible for import or export in a VRF, based on the route target extended community attributes of the route. The route map might, for example, deny access to selected routes from a community that is on the import route target list.

SUMMARY STEPS

1. **configure terminal**
2. **install feature-set mpls**
3. **feature-set mpls**
4. **feature-set mpls l3vpn**
5. **vrf context** *vrf-name*
6. **rd** *route-distinguisher*
7. **address-family { ipv4 | ipv6 } unicast**
8. **route-target** { **import** | **export** } *route-target-ext-community* **}**
9. **maximum routes** *max-routes* [**threshold** *value*] [**reinstall**]
10. **import** [**vrf default** *max-prefix*] **map** *route-map*
11. **show vrf** *vrf-name*
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**install feature-set mpls**
	Example:
	`switch(config)# install feature-set mpls`
	`switch(config)#`
		Installs the MPLS feature set.

	Command or Action	Purpose

Step 3	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

Step 4	**feature-set mpls l3vpn**
	Example:
	`switch(config)# feature-set mpls l3vpn`
	`switch(config)#`
		Enables the MPLS Layer 3 VPN feature.

Step 5	**vrf context** *vrf-name*
	Example:
	`switch(config)# vrf context vpn1`
	`switch(config-vrf)#`
		Defines the VPN routing instance by assigning a VRF name and enters VRF configuration mode. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 6	**rd** *route-distinguisher*
	Example:
	`switch(config-vrf)# rd 1.2:1`
	`switch(config-vrf)#`
		Configures the route distinguisher. The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter an RD in either of these formats:
		• 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3
		• 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-vrf)# address-family ipv4 unicast`
	`switch(config-vrf-af-ipv4)#`
		Specifies the IPv4 address family type and enters address family configuration mode.

Step 8	**route-target** { **import** | **export** } *route-target-ext-community* **}**
	Example:
	`switch(config-vrf-af-ipv4)# route-target import 1.0:1`
		Specifies a route-target extended community for a VRF as follows:
		• The import keyword imports routing information from the target VPN extended community.
		• The export keyword exports routing information to the target VPN extended community.
		• The route-target-ext-community argument adds the route-target extended community attributes to the VRF's list of import or export route-target extended communities. You can enter the route-target-ext-community argument in either of these formats:
		  • 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3

	Command or Action	Purpose
		• 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1
Step 9	**maximum routes** *max-routes* [**threshold** *value*] [**reinstall**] **Example:** `switch(config-vrf-af-ipv4)# maximum routes 10000`	(Optional) Configures the maximum number of routes that can be stored in the VRF route table. The max-routes range is from 1 to 4294967295. The threshold value range is from 1 to 100.

Step 10	**import** [**vrf default** *max-prefix*] **map** *route-map*
	Example:
	`switch(config-vrf-af-ipv4)# import vrf default map vpn1-route-map`
		(Optional) Configures an import policy for a VRF to import prefixes from the default VRF as follows:
		• The max-prefix range is from 1 to 2147483647. The default is 1000 prefixes.
		• The route-map argument specifies the route map to be used as an import route map for the VRF and can be any case-sensitive, alphanumeric string up to 63 characters.

Step 11	**show vrf** *vrf-name* **Example:** `switch(config-vrf-af-ipv4)# show vrf vpn1`	(Optional) Displays information about a VRF. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 12	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring VRF Interfaces on PE Routers for Each VPN Customer

You can associate a virtual routing and forwarding instance (VRF) with an interface or subinterface on the PE routers.

SUMMARY STEPS

1. **configure terminal**
2. **interface** *type number*
3. **vrf member** *vrf-name*
4. **show vrf** *vrf-name* **interface**
5. **copy running-config startup-config**

DETAILED STEPS

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

	Command or Action	Purpose

	`switch# configure terminal`
	`switch(config)#`	

Step 2	**interface** *type number*
	Example:
	`switch(config)# interface Ethernet 5/0`
	`switch(config-if)#`
		Specifies the interface to configure and enters interface configuration mode as follows:
		• The type argument specifies the type of interface to be configured.
		• The number argument specifies the port, connector, or interface card number.

Step 3	**vrf member** *vrf-name* **Example:** `switch(config-if)# vrf member vpn1`	Associates a VRF with the specified interface or subinterface. The vrf-name argument is the name assigned to a VRF.
Step 4	**show vrf** *vrf-name* **interface** **Example:** `switch(config-if)# show vrf vpn1 interface`	(Optional) Displays information about interfaces associated with a VRF. The vrf-name argument is any case-sensitive alphanumeric string up to 32 characters.
Step 5	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring Routing Protocols Between the PE and CE Routers

Configuring Static or Directly Connected Routes Between the PE and CE Routers

You can configure the PE router for PE-to-CE routing sessions that use static routes.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *vrf-name*
3. { **ip ipv6** } **route** *prefix nexthop*
4. **address-family { ipv4 | ipv6 } unicast**
5. **feature bgp** *as - number*
6. **router bgp** *as - number*
7. **vrf** *vrf-name*
8. **address-family { ipv4 | ipv6 } unicast**
9. **redistribute static route-map** *map-name*
10. **redistribute direct route-map** *map-name*
11. **show { ipv4 | ipv6 } route vrf** *vrf-name*
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**vrf context** *vrf-name*
	Example:
	`switch(config)# vrf context vpn1`
	`switch(config-vrf)#`
		Defines the VPN routing instance by assigning a VRF name and enters VRF configuration mode. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 3	{ **ip** **ipv6** } **route** *prefix nexthop* **Example:** `switch(config-vrf)# ip route 192.0.2.1/28 ethernet 2/1`	Defines static route parameters for every PE-to-CE session. The prefix and nexthop are as follows: • IPv4—in dotted decimal notation • IPv6—in hex format.

Step 4	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-vrf)# address-family ipv4 unicast`
	`switch(config-vrf-af)#`
		Specifies the IPv4 address family type and enters address family configuration mode.

Step 5	**feature bgp** *as - number*
	Example:
	`switch(config-vrf-af)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 6	**router bgp** *as - number* **Example:** `switch(config)# router bgp 1.1`	Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information. 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.

Step 7	**vrf** *vrf-name*
	Example:
	`switch(config-router)# vrf vpn1`
	`switch(config--router-vrf)#`
		Associates the BGP process with a VRF.
		The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 8	**address-family { ipv4 | ipv6 } unicast** **Example:**	Specifies the IPv4 address family type and enters address family configuration mode.

	Command or Action	Purpose

	`switch(config-vrf)# address-family ipv4 unicast`
	`switch(config-vrf-af)#`	

Step 9	**redistribute static route-map** *map-name* **Example:** `switch(config-router-vrf-af)# redistribute static route-map StaticMap`	Redistributes static routes into BGP. The map-name can be any case-sensitive, alphanumeric string up to 63 characters.
Step 10	**redistribute direct route-map** *map-name* **Example:** `switch(config-router-vrf-af)# redistribute direct route-map StaticMap`	Redistributes directly connected routes into BGP. The map-name can be any case-sensitive, alphanumeric string up to 63 characters.
Step 11	**show { ipv4 | ipv6 } route vrf** *vrf-name* **Example:** `switch(config-router-vrf-af)# show ip ipv4 route vrf vpn1`	(Optional) Displays information about routes. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 12	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring BGP as the Routing Protocol Between the PE and CE Routers

You can use eBGP to configure the PE router for PE-to-CE routing sessions.

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **router bgp** *as - number*
4. **vrf** *vrf-name*
5. **neighbor** *ip-address***remote-as** *as-number*
6. **address-family { ipv4 | ipv6 } unicast**
7. **show bgp { vpnv4 | vpnv6 } unicast neighbors vrf** *vrf-name*
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

	Command or Action	Purpose

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 3	**router bgp** *as - number*
	Example:
	`switch(config)# router bgp 1.1`
	`switch(config-router)#`
		Configures a BGP routing process and enters router configuration mode.
		The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 4	**vrf** *vrf-name*
	Example:
	`switch(config-router)# vrf vpn1`
	`switch(config--router-vrf)#`
		Associates the BGP process with a VRF.
		The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 5	**neighbor** *ip-address***remote-as** *as-number*
	Example:
	`switch(config-router)# neighbor 209.165.201.1 remote-as 1.1`
	`switch(config-router-neighbor)#`
		Adds an entry to the iBGP neighbor table. The ip-address argument specifies the IP address of the neighbor in dotted decimal notation. The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 6	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-vrf)# address-family ipv4 unicast`
	`switch(config-vrf-af)#`
		Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard IPv4 or IPv6 address prefixes.

Step 7	**show bgp { vpnv4 | vpnv6 } unicast neighbors vrf** *vrf-name* **Example:** `switch(config-router-neighbor-af)# show bgp vpnv4 unicast neighbors`	(Optional) Displays information about BGP neighbors. The vrf-name argument is any case-sensitive alphanumeric string up to 32 characters.
Step 8	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring RIPv2 Between the PE and CE Routers

You can use RIP to configure the PE router for PE-to-CE routing sessions.

SUMMARY STEPS

1. **configure terminal**
2. **feature rip**
3. **router rip** *instance-tag*
4. **vrf** *vrf-name*
5. **address-family ipv4 unicast**
6. **redistribute** { **bgp** as | **direct** | { **egrip** | **ospf** | **rip** } *instance-tag* | static } **route-map** *map-name vrf-name*
7. **show ip rip vrf** *vrf-name*
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature rip**
	Example:
	`switch(config)# feature rip`
	`switch(config)#`
		Enables the RIP feature.

Step 3	**router rip** *instance-tag* **Example:** `switch(config)# router rip Test1`	Enables RIP and enters router configuration mode. The instance-tag can be any case-sensitive, alphanumeric string up to 20 characters.

Step 4	**vrf** *vrf-name*
	Example:
	`switch(config-router)# vrf vpn1`
	`switch(config--router-vrf)#`
		Associates the RIP process with a VRF.
		The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 5	**address-family ipv4 unicast**
	Example:
	`switch(config-router-vrf)# address-family ipv4 unicast`
	`switch(config-router-vrf-af)#`
		Specifies the address family type and enters address family configuration mode.

Step 6	**redistribute** { **bgp** as	**direct**	{ **egrip**	**ospf**	**rip** } *instance-tag*	static } **route-map** *map-name vrf-name* **Example:** `switch(config-router-vrf-af)# show ip rip vrf vpn1`	Redistributes routes from one routing domain into another routing domain. 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. The instance-tag can be any case-sensitive alphanumeric string up to 20 characters

	Command or Action	Purpose
Step 7	**show ip rip vrf** *vrf-name* **Example:** `switch(config-router-vrf-af)# show ip rip vrf vpn1`	(Optional) Displays information about RIP. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 8	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring OSPF Between the PE and CE Routers

You can use OSPFv2 to configure the PE router for PE-to-CE routing sessions. You can optionally create an OSPF sham link if you have OSPF back door links that are not part of the MPLS network.

SUMMARY STEPS

1. **configure terminal**
2. **feature ospf**
3. **router ospf** *instance-tag*
4. **vrf** *vrf-name*
5. **area** area-id **sham-link** *source-address destination-address*
6.
7. **address-family { ipv4 | ipv6 } unicast**
8. **redistribute** { **bgp** as | **direct** | { **egrip** | **ospf** | **rip** } *instance-tag* | static } **route-map** *map-name*
9. **autonomous-system** *as-number*
10.
11. **show ip egrip vrf** *vrf-name*
12. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature ospf**
	Example:
	`switch(config)# feature ospf`
	`switch(config)#`
		Enables the OSPF feature.

Step 3	**router ospf** *instance-tag* **Example:** `switch(config)# router ospf Test1`	Enables OSPF and enters router configuration mode. The instance-tag can be any case-sensitive, alphanumeric string up to 20 characters.

	Command or Action	Purpose

Step 4	**vrf** *vrf-name*
	Example:
	`switch(config-router)# vrf vpn1`
	`switch(config--router-vrf)#`
		Enters router VRF configuration mode.
		The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 5	**area** area-id **sham-link** *source-address destination-address* **Example:** `switch(config-router-vrf)# area 1 sham-link 10.2.1.1 10.2.1.2`	(Optional) Configures the sham link on the PE interface within a specified OSPF area and with the loopback interfaces specified by the IP addresses as endpoints. You must configure the sham link at both PE endpoints.
Step 6		

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router)# address-family ipv4 unicast`
	`switch(config-router-vrf-af)#`
		Specifies the address family type and enters address family configuration mode.

Step 8	**redistribute** { **bgp** as | **direct** | { **egrip** | **ospf** | **rip** } *instance-tag* | static } **route-map** *map-name* **Example:** `switch(config-router-vrf-af)# redistribute bgp 1.0 route-map BGPMap`	Redistributes BGP into the EIGRP. The autonomous system number of the BGP network is configured in this step. BGP must be redistributed into EIGRP for the CE site to accept the BGP routes that carry the EIGRP information. A metric must also be specified for the BGP network. The map-name can be any case-sensitive, alphanumeric string up to 63 characters.

Step 9	**autonomous-system** *as-number*
	Example:
	`switch(config-router-vrf-af)#`
	`autonomous-system 1.3`
		(Optional) Specifies the autonomous system number for this address family for the customer site.
		The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 10		
Step 11	**show ip egrip vrf** *vrf-name* **Example:** `switch(config-router-vrf-af)# show ipv4 eigrp vrf vpn1`	(Optional) Displays information about EIGRP in this VRF. The vrf-name can be any case-sensitive, alphanumeric string up to 32 characters
Step 12	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring EIGRP Between the PE and CE Routers

You can configure the PE router to use Enhanced Interior Gateway Routing Protocol (EIGRP) between the PE and CE routers to transparently connect EIGRP customer networks through an MPLS-enabled BGP core network so that EIGRP routes are redistributed through the VPN across the BGP network as internal BGP (iBGP) routes.

Before you begin

You must configure BGP in the network core.

SUMMARY STEPS

1. **configure terminal**
2. **feature egrip**
3. **router egrip** *instance-tag*
4. **vrf** *vrf-name*
5. **address-family ipv4 unicast**
6. **redistribute** { **bgp** as-number**route-map** *map-name*
7. **show ip ospf** *instance-tag* **vrf** *vrf-name*
8. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature egrip**
	Example:
	`switch(config)# feature egrip`
	`switch(config)#`
		Enables the EGRIP feature.

Step 3	**router egrip** *instance-tag* **Example:** `switch(config)# router egrip Test1`	Configures an EIGRP instance and enters router configuration mode. The instance-tag can be any case-sensitive, alphanumeric string up to 20 characters.

Step 4	**vrf** *vrf-name*
	Example:
	`switch(config-router)# vrf vpn1`
	`switch(config--router-vrf)#`
		Enters router VRF configuration mode.
		The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

	Command or Action	Purpose

Step 5	**address-family ipv4 unicast**
	Example:
	`switch(config-router-vrf)# address-family ipv4 unicast`
	`switch(config-router-vrf-af)#`
		(Optional) Enters address family configuration mode for configuring routing sessions that use standard IPv4 address prefixes.

Step 6	**redistribute** { **bgp** as-number**route-map** *map-name* **Example:** `switch(config-router-vrf-af)# show ip rip vrf vpn1`	Redistributes routes from one routing domain into another routing domain. 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. The instance-tag can be any case-sensitive alphanumeric string up to 20 characters
Step 7	**show ip ospf** *instance-tag* **vrf** *vrf-name* **Example:** `switch(config-router-vrf-af)# show ip rip vrf vpn1`	(Optional) Displays information about OSPF.
Step 8	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring PE-CE Redistribution in BGP for the MPLS VPN

You must configure BGP to distribute the PE-CE routing protocol on every PE router that provides MPLS Layer 3 VPN services if the PE-CE protocol is not BGP.

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **router bgp** *instance-tag*
4. **router id** *ip-address*
5. **router id** *ip-address* **remote-as** *as-number*
6. **update-source loopback [0 | 1]**
7. **address-family { ipv4 | ipv6 } unicast**
8. **send-community extended**
9. **vrf** *vrf-name*
10. **address-family { ipv4 | ipv6 } unicast**
11. **redistribute** { **direct** | { **egrip** | **ospfv3** | **ospfv3** |**rip** } *instance-tag* | static } **route-map** *map-name*
12. **show bgp { ipv4 | ipv6 } unicast vrf** *vrf-name*
13. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 3	**router bgp** *instance-tag*
	Example:
	`switch(config)# router bgp 1.1`
	`switch(config-router)#`
		Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 4	**router id** *ip-address*
	Example:
	`switch(config-router)# router-id 192.0.2.255 1`
	`switch(config-router)#`
		(Optional) Configures the BGP router ID. This IP address identifies this BGP speaker. This command triggers an automatic notification and session reset for the BGP neighbor sessions.

Step 5	**router id** *ip-address* **remote-as** *as-number*
	Example:
	`switch(config-router)# neighbor 209.165.201.1 remote-as 1.2`
	`switch(config-router-neighbor)#`
		Adds an entry to the BGP or multiprotocol BGP neighbor table.The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 6	**update-source loopback [0 | 1]** **Example:** `switch(config-router-neighbor)# update-source loopback 0#`	Specifies the source address of the BGP session.

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router-neighbor)# address-family vpnv4`
	`switch(config-router-neighbor-af)#`
		Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 or VPNv6 address prefixes. The optional unicast keyword specifies VPNv4 or VPNv6 unicast address prefixes.

Step 8	**send-community extended** **Example:**	Specifies that a communities attribute should be sent to a BGP neighbor.

	Command or Action	Purpose
	`switch(config-router-neighbor-af)# send-community extended`	

Step 9	**vrf** *vrf-name*
	Example:
	`switch(config-router-neighbor-af)# vrf vpn1`
	`switch(config-router-vrf)#`
		Enters router VRF configuration mode.
		The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 10	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router-vrf)# address-family ipv4 unicast`
	`switch(config-router-vrf-af)#`
		Enters address family configuration mode for configuring routing sessions that use standard IPv4 or IPv6 address prefixes.

Step 11	**redistribute** { **direct** | { **egrip** | **ospfv3** | **ospfv3** |**rip** } *instance-tag* | static } **route-map** *map-name* **Example:** `switch(config-router-af-vrf)# redistribute eigrp Test2 route-map EigrpMap`	Redistributes routes from one routing domain into another routing domain. 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. The instance-tag can be any case-sensitive, alphanumeric string up to 20 characters. The map-name can be any case-sensitive alphanumeric string up to 63 characters.
Step 12	**show bgp { ipv4 | ipv6 } unicast vrf** *vrf-name* **Example:** `switch(config-router--vrf-af)# show bgp ipv4 unicast vrf vpn1vpn1`	(Optional) Displays information about BGP. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 13	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring a Hub-and-Spoke Topology

Configuring VRFs on the Hub PE Router

You can configure hub and spoke VRFs on the hub PE router.

SUMMARY STEPS

1. **configure terminal**
2. **install feature-set mpls**
3. **feature-set mpls**
4. **feature-set mpls l3vpn**
5. **vrf context** *vrf-hub*
6. **rd** *route-distinguisher*

7. **address-family { ipv4 | ipv6 } unicast**
8. **route-target** { **import** | **export** } route-target-ext-community **}**
9. **vrf context** *vrf-spoke*
10. **address-family { ipv4 | ipv6 } unicast**
11. **route-target** { **import** | **export** } *route-target-ext-community* **}**
12. **show running-config vrf** *vrf-name*
13. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**install feature-set mpls**
	Example:
	`switch(config)# install feature-set mpls`
	`switch(config)#`
		Installs the MPLS feature set.

Step 3	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

Step 4	**feature-set mpls l3vpn**
	Example:
	`switch(config)# feature-set mpls l3vpn`
	`switch(config)#`
		Enables the MPLS Layer 3 VPN feature.

Step 5	**vrf context** *vrf-hub*
	Example:
	`switch(config)# vrf context 2hub`
	`switch(config-vrf)#`
		Defines the VPN routing instance for the PE hub by assigning a VRF name and enters VRF configuration mode. The vrf-hub argument is any case-sensitive alphanumeric string up to 32 characters.

Step 6	**rd** *route-distinguisher*
	Example:
	`switch(config-vrf)# rd 1.2:1`
	`switch(config-vrf)#`
		Configures the route distinguisher. The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter an RD in either of these formats:
		• 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3
		• 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1

	Command or Action	Purpose

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-vrf)# address-family ipv4 unicast`
	`switch(config-vrf-af-ipv4)#`
		Specifies the IPv4 address family type and enters address family configuration mode.

Step 8	**route-target** { **import** | **export** } route-target-ext-community **}**
	Example:
	`switch(config-vrf-af-ipv4)# route-target import 1.0:1`
		Specifies a route-target extended community for a VRF as follows:
		• The **import** keyword imports routing information from the target VPN extended community.
		• The **export** keyword exports routing information to the target VPN extended community.
		• The route-target-ext-community argument adds the route-target extended community attributes to the VRF's list of import or export route-target extended communities. You can enter the route-target-ext-community argument in either of these formats:
		  • 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3
		  • 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1

Step 9	**vrf context** *vrf-spoke*
	Example:
	`switch(config-vrf-af-ipv4)# vrf context 2spokes`
	`switch(config-vrf)#`
		Defines the VPN routing instance for the PE spoke by assigning a VRF name and enters VRF configuration mode. The vrf-spoke argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 10	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-vrf)# address-family ipv4 unicast`
	`switch(config-vrf-af-ipv4)#`
		Specifies the IPv4 address family type and enters address family configuration mode.

Step 11	**route-target** { **import** | **export** } *route-target-ext-community* **}**
	Example:
	`switch(config-vrf-af-ipv4)# route-target export 1:100`
		Specifies a route-target extended community for a VRF as follows:
		• Creates a route-target extended community for a VRF. The **import** keyword imports routing information from the target VPN extended community. The **export** keyword exports routing information to the target VPN extended community. The route-target-ext-community argument adds the route-target extended community attributes to the VRF's list of import or export route-target extended

	Command or Action	Purpose
		communities. You can enter the route-target-ext-community argument in either of these formats: • 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3 • 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1
Step 12	**show running-config vrf** *vrf-name* **Example:** `switch(config-vrf-af-ipv4)# show running-config vrf 2spokes`	(Optional) Displays the running configuration for the VRF. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters. .
Step 13	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring eBGP on the Hub PE Router

You can use eBGP to configure PE-to-CE hub routing sessions.

Note If all CE sites are using the same BGP AS number, you must perform the following tasks:

- Configure either the BGP **as-override** command at the PE (hub) **or the allowas-in** command at the receiving CE router.
- To advertise BGP routes learned from one ASN back to the same ASN, configure the **disable-peer-as-check** command at the PE router to prevent loopback.

SUMMARY STEPS

1. **configure terminal**
2. **feature-set mpls**
3. **feature mpls l3vpn**
4. **feature bgp**
5. **router bgp** *as - number*
6. **neighbor** *ip-address***remote-as** *as-number*
7. **address-family { ipv4 | ipv6 } unicast**
8. **send-community extended**
9. **vrf** *vrf-hub*
10. **neighbor** *ip-address***remote-as** *as-number*
11. **address-family { ipv4 | ipv6 } unicast**

12. **as-override**
13. **vrf** *vrf-spoke*
14. **neighbor** *ip-address***remote-as** *as-number*
15. **address-family { ipv4 | ipv6 } unicast**
16. **allowas-in** [*number*]
17. **show running-config bgp** *vrf-name*
18. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature-set mpls** **Example:** `switch(config)# feature-set mpls`	Enables the MPLS feature-set.
Step 3	**feature mpls l3vpn** **Example:** `switch(config)# feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature.

Step 4	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 5	**router bgp** *as - number*
	Example:
	`switch(config)# router bgp 1.1`
	`switch(config-router)#`
		Configures a BGP routing process and enters router configuration mode.
		The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 6	**neighbor** *ip-address***remote-as** *as-number*
	Example:
	`switch(config-router)# neighbor 209.165.201.1 remote-as 1.2`
	`switch(config-router-neighbor)#`
		Adds an entry to the iBGP neighbor table.
		• The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.
		• The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 7	**address-family { ipv4 | ipv6 } unicast** **Example:**	Specifies the IP address family type and enters address family configuration mode.

	Command or Action	Purpose
	switch(config-router-vrf-neighbor)# address-family ipv4 unicast switch(config-router-neighbor-af)#	
Step 8	**send-community extended** **Example:** switch(config-router-neighbor-af)# send-community extended	(Optional) Configures BGP to advertise extended community lists.
Step 9	**vrf** *vrf-hub* **Example:** switch(config-router-neighbor-af)# vrf 2hub switch(config-router-vrf)#	Enters VRF configuration mode. The *vrf-hub* argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 10	**neighbor** *ip-address***remote-as** *as-number* **Example:** switch(config-router-vrf)# neighbor 33.0.0.33 1 remote-as 150 switch(config-router-vrf-neighbor)#	Adds an entry to the BGP or multiprotocol BGP neighbor table for this VRF. • The ip-address argument specifies the IP address of the neighbor in dotted decimal notation. • The as-number argument specifies the autonomous system to which the neighbor belongs.
Step 11	**address-family { ipv4 | ipv6 } unicast** **Example:** switch(config-router-vrf-neighbor)# address-family ipv4 unicast switch(config-router--vrf-neighbor-af)#	Specifies the IP address family type and enters address family configuration mode.
Step 12	**as-override** **Example:** switch(config-router-vrf-neighbor-af)# as-override	(Optional) Overrides the AS-number when sending an update. If all BGP sites are using the same AS number, of the following commands: • Configure the BGP as-override command at the PE (hub) or • Configure the allowas-in command at the receiving CE router.
Step 13	**vrf** *vrf-spoke* **Example:** switch(config-router-vrf-neighbor-af)# vrf 2spokes switch(config-router-vrf)#	Enters VRF configuration mode. The vrf-spoke argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 14	**neighbor** *ip-address***remote-as** *as-number* **Example:** switch(config-router-vrf)# neighbor 33.0.0.33 1 remote-as 150 switch(config-router-vrf-neighbor)#	Adds an entry to the BGP or multiprotocol BGP neighbor table for this VRF. • The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.

	Command or Action	Purpose
		• The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 15	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router-vrf-neighbor)# address-family ipv4 unicast`
	`switch(config-router--vrf-neighbor-af)#`
		Specifies the IP address family type and enters address family configuration mode.

Step 16	**allowas-in** [*number*] **Example:** `switch(config-router-vrf-neighbor-af)# allowas-in 3`	(Optional) Allows duplicate AS numbers in the AS path. Configure this parameter in the VPN address family configuration mode at the PE spokes and at the neighbor mode at the PE hub.
Step 17	**show running-config bgp** *vrf-name* **Example:** `switch(config-router-vrf-neighbor-af)# show running-config bgp`	(Optional) Displays the running configuration for BGP.
Step 18	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring eBGP on the Hub CE Router

You can use eBGP to configure PE-to-CE hub routing sessions.

Note Note If all CE sites are using the same BGP AS number, you must perform the following tasks:

- Configure either the as-override command at the PE (hub) or the allowas-in command at the receiving CE router.
- Configure the disable-peer-as-check command at the CE router.
- To advertise BGP routes learned from one ASN back to the same ASN, configure the disable-peer-as-check command at the PE router to prevent loopback.

SUMMARY STEPS

1. **configure terminal**
2. **feature-set mpls**
3. **feature mpls l3vpn**
4. **feature bgp**
5. **router bgp** *as - number*
6. **neighbor** *ip-address***remote-as** *as-number*

7. **address-family { ipv4 | ipv6 } unicast**
8. **send-community extended**
9. **vrf** *vrf-hub*
10. **neighbor** *ip-address***remote-as** *as-number*
11. **address-family { ipv4 | ipv6 } unicast**
12. **as-override**
13. **vrf** *vrf-spoke*
14. **neighbor** *ip-address***remote-as** *as-number*
15. **address-family { ipv4 | ipv6 } unicast**
16. **allowas-in** [*number*]
17. **show running-config bgp** *vrf-name*
18. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature-set mpls** **Example:** `switch(config)# feature-set mpls`	Enables the MPLS feature-set.
Step 3	**feature mpls l3vpn** **Example:** `switch(config)# feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature.

Step 4	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 5	**router bgp** *as - number*
	Example:
	`switch(config)# router bgp 1.1`
	`switch(config-router)#`
		Configures a BGP routing process and enters router configuration mode.
		The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 6	**neighbor** *ip-address***remote-as** *as-number* **Example:**	Adds an entry to the iBGP neighbor table. • The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.

	Command or Action	Purpose

	`switch(config-router)# neighbor 209.165.201.1`
	`remote-as 1.2`
	`switch(config-router-neighbor)#`
		• The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router-vrf-neighbor)# address-family`
	` ipv4 unicast`
	`switch(config-router-neighbor-af)#`
		Specifies the IP address family type and enters address family configuration mode.

Step 8	**send-community extended**
	Example:
	`switch(config-router-neighbor-af)# send-community`
	` extended`
		(Optional) Configures BGP to advertise extended community lists.

Step 9	**vrf** *vrf-hub*
	Example:
	`switch(config-router-neighbor-af)# vrf 2hub`
	`switch(config-router-vrf)#`
		Enters VRF configuration mode. The *vrf-hub* argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 10	**neighbor** *ip-address***remote-as** *as-number*
	Example:
	`switch(config-router-vrf)# neighbor 33.0.0.33 1`
	`remote-as 150`
	`switch(config-router-vrf-neighbor)#`
		Adds an entry to the BGP or multiprotocol BGP neighbor table for this VRF.
		• The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.
		• The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 11	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router-vrf-neighbor)# address-family`
	` ipv4 unicast`
	`switch(config-router--vrf-neighbor-af)#`
		Specifies the IP address family type and enters address family configuration mode.

Step 12	**as-override** **Example:** `switch(config-router-vrf-neighbor-af)# as-override`	(Optional) Overrides the AS-number when sending an update. If all BGP sites are using the same AS number, of the following commands: • Configure the BGP as-override command at the PE (hub) or • Configure the allowas-in command at the receiving CE router.

Step 13	**vrf** *vrf-spoke*
	Example:
	`switch(config-router-vrf-neighbor-af)# vrf 2spokes`
	`switch(config-router-vrf)#`
		Enters VRF configuration mode. The vrf-spoke argument is any case-sensitive, alphanumeric string up to 32 characters.

	Command or Action	Purpose

Step 14	**neighbor** *ip-address***remote-as** *as-number*
	Example:
	`switch(config-router-vrf)# neighbor 33.0.0.33 1 remote-as 150`
	`switch(config-router-vrf-neighbor)#`
		Adds an entry to the BGP or multiprotocol BGP neighbor table for this VRF.
		• The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.
		• The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 15	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router-vrf-neighbor)# address-family ipv4 unicast`
	`switch(config-router--vrf-neighbor-af)#`
		Specifies the IP address family type and enters address family configuration mode.

Step 16	**allowas-in** [*number*] **Example:** `switch(config-router-vrf-neighbor-af)# allowas-in 3`	(Optional) Allows duplicate AS numbers in the AS path. Configure this parameter in the VPN address family configuration mode at the PE spokes and at the neighbor mode at the PE hub.
Step 17	**show running-config bgp** *vrf-name* **Example:** `switch(config-router-vrf-neighbor-af)# show running-config bgp`	(Optional) Displays the running configuration for BGP.
Step 18	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring VRFs on the Spoke PE Router

You can configure hub and spoke VRFs on the spoke PE router.

SUMMARY STEPS

1. **configure terminal**
2. **install feature-set mpls**
3. **feature-set mpls**
4. **feature-set mpls l3vpn**
5. **vrf context** *vrf-spoke*
6. **rd** *route-distinguisher*
7. **address-family { ipv4 | ipv6 } unicast**
8. **route-target** { **import** | **export** } route-target-ext-community **}**
9. **show running-config vrf** *vrf-name*
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**install feature-set mpls**
	Example:
	`switch(config)# install feature-set mpls`
	`switch(config)#`
		Installs the MPLS feature set.

Step 3	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

Step 4	**feature-set mpls l3vpn**
	Example:
	`switch(config)# feature-set mpls l3vpn`
	`switch(config)#`
		Enables the MPLS Layer 3 VPN feature.

Step 5	**vrf context** *vrf-spoke*
	Example:
	`switch(config)# vrf context spoke`
	`switch(config-vrf)#`
		Defines the VPN routing instance for the PE spoke by assigning a VRF name and enters VRF configuration mode. The vrf-spoke argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 6	**rd** *route-distinguisher*
	Example:
	`switch(config-vrf)# rd 1.101`
	`switch(config-vrf)#`
		Configures the route distinguisher. The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter an RD in either of these formats:
		• 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3
		• 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-vrf)# address-family ipv4 unicast`
	`switch(config-vrf-af-ipv4)#`
		Specifies the IPv4 address family type and enters address family configuration mode.

Step 8	**route-target** { **import** | **export** } route-target-ext-community **}** **Example:**	Specifies a route-target extended community for a VRF as follows: • The **import** keyword imports routing information from the target VPN extended community.

	Command or Action	Purpose
	`switch(config-vrf-af-ipv4)# route-target import 1.0:1`	• The **export** keyword exports routing information to the target VPN extended community. • The route-target-ext-community argument adds the route-target extended community attributes to the VRF's list of import or export route-target extended communities. You can enter the route-target-ext-community argument in either of these formats: • 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3 • 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1
Step 9	**show running-config vrf** *vrf-name* **Example:** `switch(config-vrf-af-ipv4)# show running-config vrf 2spokes`	(Optional) Displays the running configuration for the VRF. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters. .
Step 10	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring eBGP on the Spoke PE Router

You can use eBGP to configure PE spoke routing sessions.

Note If all CE sites are using the same BGP AS number, you must perform the following tasks:

- Configure the the allowas-in command at the receiving spoke router.

SUMMARY STEPS

1. **configure terminal**
2. **feature-set mpls**
3. **feature mpls l3vpn**
4. **feature bgp**
5. **router bgp** *as - number*
6. **neighbor** *ip-address***remote-as** *as-number*
7. **address-family { ipv4 | ipv6 } unicast**
8. **allowas-in** *number*
9. **send-community extended**

10. **show running-config bgp**
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature-set mpls** **Example:** `switch(config)# feature-set mpls`	Enables the MPLS feature-set.
Step 3	**feature mpls l3vpn** **Example:** `switch(config)# feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature.

Step 4	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 5	**router bgp** *as - number*
	Example:
	`switch(config)# router bgp 100`
	`switch(config-router)#`
		Configures a BGP routing process and enters router configuration mode.
		The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 6	**neighbor** *ip-address***remote-as** *as-number*
	Example:
	`switch(config-router)# neighbor 63.63.0.63 remote-as 100`
	`switch(config-router-neighbor)#`
		Adds an entry to the iBGP neighbor table.
		• The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.
		• The as-number argument specifies the autonomous system to which the neighbor belongs.

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router-vrf-neighbor)# address-family ipv4 unicast`
	`switch(config-router-neighbor-af)#`
		Specifies the IPv4 or IPv6 address family type and enters address family configuration mode.

	Command or Action	Purpose
Step 8	**allowas-in** *number* **Example:** `switch(config-router-vrf-neighbor-af)# allowas-in 3`	(Optional) Allows an AS path with the PE ASN for a specified number of times. • The range is from 1 to 10 • If all BGP sites are using the same AS number, of the following commands: **Note** Configure the BGP as-override command at the PE (hub) or Configure the allowas-in command at the receiving CE router. The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.
Step 9	**send-community extended** **Example:** `switch(config-router-neighbor)# send-community extended`	(Optional) Configures BGP to advertise extended community lists.
Step 10	**show running-config bgp** **Example:** `switch(config-router-vrf-neighbor-af)# show running-config bgp`	(Optional) Displays the running configuration for BGP.
Step 11	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring MPLS using Hardware Profile Command

Beginning with release 7.0(3)F3(3), Cisco Nexus 3600 supports multiple hardware profiles. You can configure MPLS and/or VXLAN using hardware profile configuration command in a switch. The hardware profile configuration command invokes appropriate configuration files that are available on the switch. VXLAN is enabled by default

Before you begin

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **hardware profile** [**vxlan** | **mpls**] **module all**

4. **show hardware profile module** [**all** | *number*]
5. **show module internal sw info** | [**i** | **mpls**]
6. **show running configuration** | [**i** | **mpls**]

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 3	**hardware profile** [**vxlan** | **mpls**] **module all** **Example:** `switch(config)# hardware profile mpls  module all`	Enables MPLS on all the switch modules. .

Step 4	**show hardware profile module** [**all** | *number*]
	Example:
	`switch(config)# show hardware profile module all`
	`switch(config)#`
		Displays the hardware profile of all the modules or specific module.

Step 5	**show module internal sw info** | [**i** | **mpls**] **Example:** `switch(config)# show module internal sw info`	Displays the switch software information.
Step 6	**show running configuration** | [**i** | **mpls**] **Example:** `switch(config)# show module internal sw info`	Displays the running configuration.

CHAPTER 5

Configuring MPLS Layer 3 VPN Label Allocation

This chapter describes how to configure label allocation for Multiprotocol Label Switching (MPLS) Layer 3 virtual private networks (L3VPNs) on Cisco Nexus 3600 series Switches.

Information About MPLS L3VPN Label Allocation

The MPLS provider edge (PE) router stores both local and remote routes and includes a label entry for each route. By default, Cisco NX-OS uses per-prefix label allocation which means that each prefix is assigned a label. For distributed platforms, the per-prefix labels consume memory. When there are many VPN routing and forwarding instances (VRFs) and routes, the amount of memory that the per-prefix labels consume can become an issue.

You can enable per-VRF label allocation to advertise a single VPN label for local routes throughout the entire VRF. The router uses a new VPN label for the VRF decoding and IP-based lookup to learn where to forward packets for the PE or customer edge (CE) interfaces.

You can enable different label allocation modes for Border Gateway Protocol (BGP) Layer 3 VPN routes to meet different requirements and to achieve trade-offs between scalability and performance. All labels are allocated within the global label space. Cisco NX-OS supports the following label allocation modes:

- Per-prefix—A label is allocated for each VPN prefix. VPN packets received from remote PEs can be directly forwarded to the connected CE that advertised the prefix, based on the label forwarding table. However, this mode also uses many labels. This mode is the only mode available when VPN packets sent from PE to CE are label switched. This is the default label allocation mode.

- Per-VRF—A single label is assigned to all local VPN routes in a VRF. This mode requires an IPv4 or IPv6 lookup in the VRF forwarding table once the VPN label is removed at the egress PE. This mode is the most efficient in terms of label space as well as BGP advertisements, and the lookup does not result in any performance degradation. Cisco NX-OS uses the same per-VRF label for both IPv4 and IPv6 prefixes.

Note EIBGP load balancing is not supported for a VRF that uses per-VRF label mode

- Aggregate Labels—BGP can allocate and advertise a local label for an aggregate prefix. Forwarding requires an IPv4 or IPv6 lookup that is similar to the per-VRF scenario. A single per-VRF label is allocated and used for all prefixes that need a lookup.
- VRF connected routes—When directly connected routes are redistributed and exported, an aggregate label is allocated for each route. The packets that come in from the core are decapsulated and a lookup is done in the VRF IPv4 or IPv6 table to determine whether the packet is for the local router or for another router or host that is directly connected. A single per-VRF label is allocated for all such routes.
- Label hold down—When a local label is no longer associated with a prefix, to allow time for updates to be sent to other PEs, the local label is not released immediately. A ten minute hold down timer is started per label. Within this hold down period, the label can be reclaimed for the prefix. When the timer expires, BGP releases the label.

IPv6 Label Allocation

IPv6 prefixes are advertised with the allocated label to iBGP peers that have the labeled-unicast address-family enabled. The received eBGP next hop is not propagated to such peers; instead, the local IPv4 session address is sent as an IPv4-mapped IPv6 next hop. The remote peer resolves this next hop through one or more IPv4 MPLS LSPs in the core network.

You can use a route reflector to advertise the labeled 6PE prefixes between PEs. You must enable the labeled-unicast address-family between the route reflector and all such peers. The route reflector does not need to be in the forwarding path and propagates the received next hop as is to iBGP peers and route reflector clients.

Note 6PE also supports both per-prefix and per-VRF label allocation modes, as in 6VPE

Per-VRF Label Allocation Mode

The following conditions apply when you configure per-VRF label allocation:

- The VRF uses one label for all local routes.
- When you enable per-VRF label allocation, any existing per-VRF aggregate label is used. If no per-VRF aggregate label is present, the software creates a new per-VRF label.

  The CE does not lose data when you disable per-VRF label allocation because the configuration reverts to the default per-prefix labeling configuration.
- A per-VRF label forwarding entry is deleted only if the VRF, BGP, or address family configuration is removed.

About Labeled and Unlabeled Unicast Paths

Subsequent Address Family Identifier (SAFI) is an indication of the BGP route. Example 1 is for an unlabeled route and 4 for a labeled route.

- Unlabeled unicast (U) for IPv4 is SAFI 1.
- Labeled unicast (LU) for IPv4 is SAFI 4.
- Unlabeled unicast (U) for IPv6 is AFI 2 and SAFI 1.
- Labeled unicast (LU) for IPv6 is AFI 2 and SAFI 4.

Cisco NX-OS Release 9.2(2) supports both, IPv4 and IPv6 unlabeled and labeled unicast on one BGP session. This behavior is the same irrespective of whether one or both SAFI-1 and SAFI-4 are enabled on the same session or not.

This behavior is applicable for all eBGP, iBGP, and redistributed paths and the eBGP and iBGP neighbors.

Prerequisites for MPLS L3VPN Label Allocation

L3VPN label allocation has the following prerequisites:

- Ensure that you have configured MPLS, and LDP in your network. All routers in the core, including the PE routers, must be able to support MPLS forwarding.
- Ensure that you have installed the correct license for MPLS and any other features you will be using with MPLS.
- Ensure that you disable the external/internal Border Gateway Protocol (BGP) multipath feature if it is enabled before you configure per-VRF label allocation mode.
- Before configuring a 6VPE per VRF label, ensure that the IPv6 address family is configured on that VRF.

Guidelines and Limitations for MPLS L3VPN Label Allocation

L3VPN label allocation has the following configuration guidelines and limitations:

- Layer 3 VPN label allocation is also supported on the Cisco Nexus 3600 platform switches.
- Enabling per-VRF label allocation causes BGP reconvergence, which can result in data loss for traffic coming from the MPLS VPN core.

Note You can minimize network disruption by enabling per-VRF label allocation during a scheduled MPLS maintenance window. Also, if possible, avoid enabling this feature on a live router.

- Aggregate labels and per-VRF labels are global across all virtual device contexts (VDCs) and are in a separate, dedicated label range.

- Aggregate prefixes for per-prefix label allocation share the same label in a given VRF.

Default Settings for MPLS L3VPN Label Allocation

Table 3: Default L3VPN Label Allocation Parameters

Parameters	Default
L3VPN feature	Disabled
Label allocation mode	Per prefix

Configuring MPLS L3VPN Label Allocation

Configuring Per-VRF L3VPN Label Allocation Mode

You can configure per-VRF L3VPN label allocation mode for Layer 3 VPNs.

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **feature-set mpls**
4. **feature-set mpls l3vpn**
5. **router bgp** *as - number*
6. **vrf** *vrf-name*
7. **address-family { ipv4 | ipv6 } unicast | multicast }**
8. **label-allocation-mode per-vrf**
9. **show bgp l3vpn detail vrf** *vrf-name*
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

	Command or Action	Purpose

Step 3	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

Step 4	**feature-set mpls l3vpn**
	Example:
	`switch(config)# feature-set mpls l3vpn`
	`switch(config)#`
		Enables the MPLS Layer 3 VPN feature.

Step 5	**router bgp** *as - number* **Example:** `switch(config)# router bgp 1.1`	Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information. 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.
Step 6	**vrf** *vrf-name* **Example:** `switch(config-router)# vrf vpn1`	Enters router VRF configuration mode. The vrf-name can be any case-sensitive, alphanumeric string up to 32 characters..

Step 7	**address-family { ipv4 | ipv6 } unicast | multicast }**
	Example:
	`switch(config-router-vrf)# address-family ipv6 unicast`
		Specifies the IP address family type and enters address family configuration mode.

Step 8	**label-allocation-mode per-vrf** **Example:** `switch(config-router-vrf-af)# label-allocation-mode per-vrf`	Allocates labels on a per-VRF basis.
Step 9	**show bgp l3vpn detail vrf** *vrf-name* **Example:** `switch(config-router-vrf-af)# show bgp l3vpn detail vrf vpn1`	(Optional) Displays information about Layer 3 VPN configuration on BGP for this VRF. The vrf-name can be any case-sensitive, alphanumeric string up to 32 characters.
Step 10	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Allocating Labels for IPv6 Prefixes in the Default VRF

If you are running IPv6 over an IPv4 MPLS core network (6PE), you can allocate labels for the IPv6 prefixes in the default VRF.

Note By default, labels are not allocated for IPv6 prefixes in the default VRF.

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **feature-set mpls**
4. **feature-set mpls l3vpn**
5. **router bgp** *as - number*
6. **address-family { ipv4 | ipv6 } unicast | multicast }**
7. **allocate-label { all | route-map** *route-map* **}**
8. **show running-config bgp**
9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 3	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

Step 4	**feature-set mpls l3vpn**
	Example:
	`switch(config)# feature-set mpls l3vpn`
	`switch(config)#`
		Enables the MPLS Layer 3 VPN feature.

Step 5	**router bgp** *as - number* **Example:** `switch(config)# router bgp 1.1`	Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information. 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.

	Command or Action	Purpose

Step 6	**address-family { ipv4 | ipv6 } unicast | multicast }**
	Example:
	`switch(config-router-vrf)# address-family ipv6 unicast`
		Specifies the IP address family type and enters address family configuration mode.

Step 7	**allocate-label { all | route-map** *route-map* **}**
	Example:
	`switch(config-router-af)# allocate-label all`
		Allocates labels for IPv6 prefixes in the default VRF.
		• The **all** keyword allocates labels for all IPv6 prefixes.
		• The **route-map** keyword allocates labels for IPv6 prefixes matched in the specified route map. The route-map can be any case-sensitive alphanumeric string up to 63 characters.

Step 8	**show running-config bgp** **Example:** `switch(config-router-af)# show running-config bgp`	(Optional) Displays information about the BGP configuration.
Step 9	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Enabling Sending MPLS Labels in IPv6 over an IPv4 MPLS Core Network (6PE) for iBGP Neighbors

6PE advertises IPv6 prefixes in global VRF over IPv4 based MPLS network with the allocated label to iBGP peers that have the labeled-unicast address-family enabled. 6PE requires LDP enabled on core facing interfaces to transport IPv6 traffic over IPv4 based MPLS network and “address-family ipv6 labeled-unicast” under BGP to exchange label for IPv6 prefixes between PEs.

Note The **address-family ipv6 labeled-unicast** command is supported only for iBGP neighbors. You cannot use this command with the **address-family ipv6 unicast** command.

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **feature-set mpls**
4. **feature-set mpls l3vpn**
5. **router bgp** *as - number*
6. **neighbor** *ip-address*
7. **address-family ipv6 labeled-unicast**
8. **show running-config bgp**

9. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 3	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

Step 4	**feature-set mpls l3vpn**
	Example:
	`switch(config)# feature-set mpls l3vpn`
	`switch(config)#`
		Enables the MPLS Layer 3 VPN feature.

Step 5	**router bgp** *as - number* **Example:** `switch(config)# router bgp 1.1`	Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information. 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.

Step 6	**neighbor** *ip-address*
	Example:
	`switch(config-router)# neighbor 209.165.201.1`
	`switch(config-router-neighbor)#`
		Adds an entry to the BGP or multiprotocol BGP neighbor table. The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.

Step 7	**address-family ipv6 labeled-unicast**
	Example:
	`switch(config-router-neighbor)# address-family ipv6 labeled-unicast`
	`switch(config-router-neighbor-af)#`
		Specifies IPv6 labeled unicast address prefixes. This command is accepted only for iBGP neighbors.

Step 8	**show running-config bgp** **Example:** `switch(config-router-af)# show running-config bgp`	(Optional) Displays information about the BGP configuration.

	Command or Action	Purpose
Step 9	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Example

What to do next

-

Advertisement and Withdraw Rules

The following table shows the advertisement and withdraw behavior for different scenarios.

Table 4: Advertisement and Withdraw Rules

Case	Bestpath/ Addpath Type	Local Label Present?	NHS or NHU	Update-group SAFI	Advertise o withdraw?
1	Unlabeled path. For example, no RX label.	Yes	NHS	SAFI-1	Advertise b default.
2				SAFI-4	Advertise
3			NHU	SAFI-1	Advertise

Case	Bestpath/ Addpath Type	Local Label Present?	NHS or NHU	Update-group SAFI	Advertise or withdraw?
4				SAFI-4	Withdraw
5		No	NHS	SAFI-1	Advertise
6				SAFI-4	Withdraw
7			NHU	SAFI-1	Advertise
8				SAFI-4	Withdraw
9	Labeled path. For example, with an RX label.	Yes	NHS	SAFI-1	Advertise by default. Withdraw with NbrKnob.
10				SAFI-4	Advertise
11			NHU	SAFI-1	Withdraw
12				SAFI-4	Advertise
13		No	NHS	SAFI-1	Advertise
14				SAFI-4	Withdraw
15			NHU	SAFI-1	Withdraw

Case	Bestpath/ Addpath Type	Local Label Present?	NHS or NHU	Update-group SAFI	Advertise o withdraw?
				SAFI-4	Advertise

Enabling Local Label Allocation

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **feature-set mpls**
4. **router bgp** *as - number*
5. **address-family { ipv4 | ipv6 } unicast | multicast }**
6. **allocate-label { all | route-map** *route-map* **}**
7. **neighbor** *ip-address*
8. [**no**] **advertise local-labeled-route**
9. **address-family { ipv4 | ipv6 } unicast | multicast }**
10. [**no**] **advertise local-labeled-route**
11. **route-map label_routemap permit 10**
12. **show running-config bgp**
13. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 3	**feature-set mpls**
	Example:
	`switch(config)# feature-set mpls`
	`switch(config)#`
		Enables the MPLS feature-set.

	Command or Action	Purpose
Step 4	**router bgp** *as - number* **Example:** `switch(config)# router bgp 1.1`	Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information. 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.

Step 5	**address-family { ipv4 | ipv6 } unicast | multicast }**
	Example:
	`switch(config-router-vrf)# address-family ipv4 unicast`
		Specifies the IP address family type and enters the address family configuration mode.

Step 6	**allocate-label { all | route-map** *route-map* **}**
	Example:
	`switch(config-router-af)# allocate-label all`
		Allocates labels for IPv6 prefixes in the default VRF.
		• The **all** keyword allocates labels for all IPv6 prefixes.
		• The **route-map** keyword allocates labels for IPv6 prefixes matched in the specified route map. The route-map can be any case-sensitive alphanumeric string up to 63 characters.

Step 7	**neighbor** *ip-address*
	Example:
	`switch(config-router)# neighbor 209.165.201.1`
	`switch(config-router-neighbor)#`
		Adds an entry to the BGP or multiprotocol BGP neighbor table. The ip-address argument specifies the IP address of the neighbor in dotted decimal notation.

Step 8	[**no**] **advertise local-labeled-route** **Example:** `switch(config-router-neighbor)# advertise local-labeled-route`	Indicates whether to advertise an IPv4 or IPv6 route with a local label to the BGP neighbor via the IPv4 or IPv6 unicast SAFI (SAFI-1). The default is enabled so that it can be advertised to the BGP neighbor.

Step 9	**address-family { ipv4 | ipv6 } unicast | multicast }**
	Example:
	`switch(config-router-vrf)# address-family ipv6 unicast`
		Specifies the IP address family type and enters the address family configuration mode.

Step 10	[**no**] **advertise local-labeled-route** **Example:** `switch(config-router-neighbor)# advertise local-labeled-route`	Indicates whether to advertise an IPv4 or IPv6 route with a local label to the BGP neighbor via the IPv4 or IPv6 unicast SAFI (SAFI-1). The default is enabled so that it can be advertised to the BGP neighbor.
Step 11	**route-map label_routemap permit 10** **Example:** `switch(config-router-vrf)# route-map label_routemap permit 10`	

	Command or Action	Purpose
Step 12	**show running-config bgp** **Example:** `switch(config-router-af)# show running-config bgp`	(Optional) Displays information about the BGP configuration.
Step 13	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Verifying MPLS L3VPN Label Allocation Configuration

To display the L3VPN label allocation configuration, perform one of the following tasks:

Table 5: Verifying MPLS L3VPN Label Allocation Configuration

Command	Purpose
show bgp l3vpn [**detail**] [**vrf** *v rf-name*]	Displays Layer 3 VPN information for BGP in a VRF.
show bgp vpnv4 unicast labels [**vrf** *v rf-name*]	Displays label information for BGP.
show ip route [**vrf** *v rf-name*]	Displays label information for routes.

Configuration Examples for MPLS L3VPN Label Allocation

The following example shows how to configure per-VRF label allocation for an IPv4 MPLS network.

```
PE1
-----
vrf context vpn1
rd 100:1
address-family ipv4 unicast
route-target export 200:1
router bgp 100
neighbor 10.1.1.2 remote-as 100
address-family vpnv4 unicast
send-community extended
update-source loopback10
vrf vpn1
address-family ipv4 unicast
label-allocation-mode per-vrf
neighbor 36.0.0.2 remote-as 300
address-family ipv4 unicast
```

CHAPTER 6

Configuring MPLS Layer 3 VPN Load Balancing

This chapter describes how to configure load balancing for Multiprotocol Label Switching (MPLS) Layer 3 virtual private networks (VPNs) on Cisco NX-OS devices.

Information About MPLS Layer 3 VPN Load Balancing

Load balancing distributes traffic so that no individual router is overburdened. In an MPLS Layer 3 network, you can achieve load balancing by using the Border Gateway Protocol (BGP). When multiple iBGP paths are installed in a routing table, a route reflector advertises only one path (next hop). If a router is behind a route reflector, all routes that are connected to multihomed sites are not advertised unless a different route distinguisher is configured for each virtual routing and forwarding instance (VRF). (A route reflector passes learned routes to neighbors so that all iBGP peers do not need to be fully meshed.)

iBGP Load Balancing

When a BGP-speaking router configured with no local policy receives multiple network layer reachability information (NLRI) from the internal BGP (iBGP) for the same destination, the router chooses one iBGP path as the best path and installs the best path in its IP routing table. iBGP load balancing enables the BGP-speaking router to select multiple iBGP paths as the best paths to a destination and to install multiple best paths in its IP routing table.

eBGP Load Balancing

When a router learns two identical eBGP paths for a prefix from a neighboring autonomous system, it chooses the path with the lower route ID as the best path. The router installs this best path in the IP routing table. You can enable eBGP load balancing to install multiple paths in the IP routing table when the eBGP paths are learned from a neighboring autonomous system instead of picking one best path.

During packet switching, depending on the switching mode, the router performs either per-packet or per-destination load balancing among the multiple paths.

Layer 3 VPN Load Balancing

ayer 3 VPN load balancing for both eBGP and iBGP allows you to configure multihomed autonomous systems and provider edge (PE) routers to distribute traffic across both external BGP (eBGP) and iBGP multipaths.

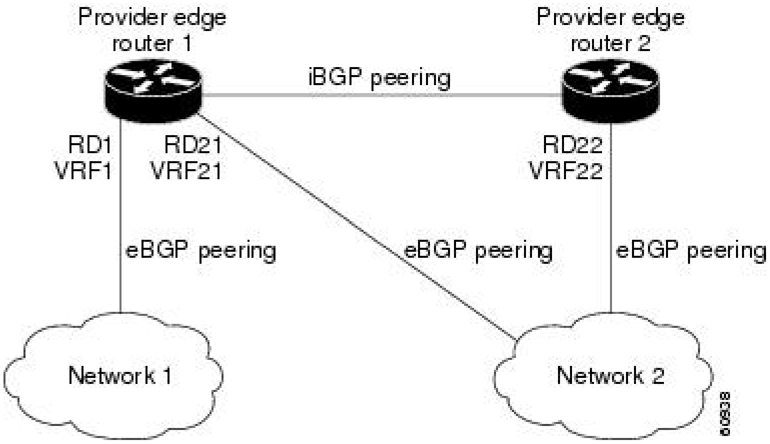
Layer 3 VPN load balancing supports IPv4 and IPv6 for the PE routers and VPNs.

BGP installs up to the maximum number of multipaths allowed. BGP uses the best path algorithm to select one path as the best path, inserts the best path into the routing information base (RIB) and advertises the best path to BGP peers. The router can insert other paths into the RIB but selects only one path as the best path.

Layer 3 VPNs load balance on a per-packet or per-source or destination pair basis. To enable load balancing, configure the router with Layer 3 VPNs that contain VPN routing and forwarding instances (VRFs) that import both eBGP and iBGP paths. You can configure the number of paths separately for each VRF.

The following figure shows an MPLS provider network that uses BGP. In the figure, two remote networks are connected to PE1 and PE2, which are both configured for VPN unicast iBGP peering. Network 2 is a multihomed network that is connected to PE1 and PE2. Network 2 also has extranet VPN services configured with Network 1. Both Network 1 and Network 2 are configured for eBGP peering with the PE routers.

Figure 4: Provider MPLS Network Using BGP



You can configure PE1 so that it can select both iBGP and eBGP paths as multipaths and import these paths into the VPN routing and forwarding instance (VRF) of Network 1 to perform load balancing.

Traffic is distributed as follows:

- IP traffic that is sent from Network 2 to PE1 and PE2 is sent across the eBGP paths as IP traffic.
- IP traffic that is sent from PE1 to PE2 is sent across the iBGP path as MPLS traffic.
- Traffic that is sent across an eBGP path is sent as IP traffic.

Any prefix that is advertised from Network 2 will be received by PE1 through route distinguisher (RD) 21 and RD22.

- The advertisement through RD21 is carried in IP packets.
- The advertisement through RD22 is carried in MPLS packets.

The router can select both paths as multipaths for VRF1 and insert these paths into the VRF1 RIB.

Layer 3 VPN Load Balancing with Route Reflectors

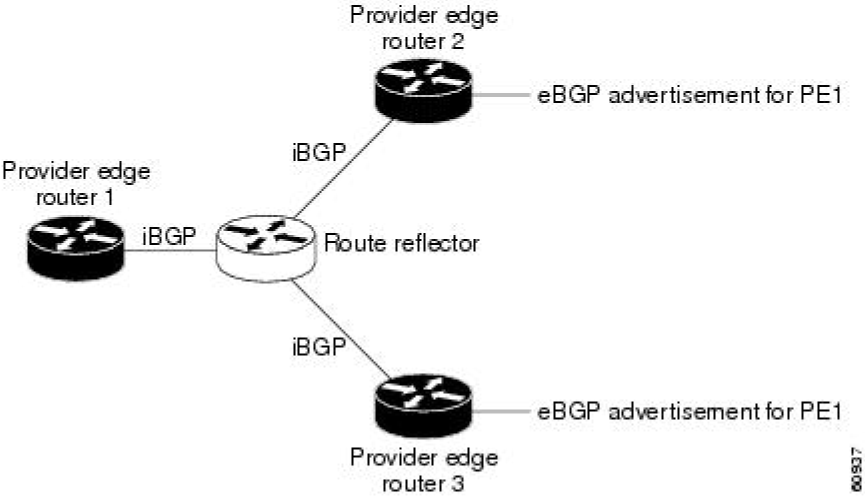
Route reflectors reduce the number of sessions on PE routers and increase the scalability of Layer 3 VPN networks. Route reflectors hold on to all received VPN routes to peer with PE routers. Different PEs can require different route target-tagged VPNv4 and VPNv6 routes. The route reflector may also need to send a refresh for a specific route target to a PE when the VRF configuration has changed. Storing all routes increases the scalability requirements on a route reflector. You can configure a route reflector to only hold routes that have a defined set of route target communities.

You can configure route reflectors to service a different set of VPNs and configure a PE to peer with all route reflectors that service the VRFs configured on the PE. When you configure a new VRF with a route target that the PE does not already hold routes for, the PE issues route refreshes to the route reflectors and retrieves the relevant VPN routes.

The following figure shows a topology that contains three PE routers and a route reflector, all configured for iBGP peering. PE2 and PE3 each advertise an equal preference eBGP path to PE1. By default, the route reflector chooses only one path and advertises PE1.

Note The route reflectors do not need to be in the forwarding path, but you must configure unique route distinguisher (RDs) for VPN sites that are multihomed.

Figure 5: Topology with a Route Reflector



For all equal preference paths to PE1 to be advertised through the route reflector, you must configure each VRF with a different RD. The prefixes received by the route reflector are recognized differently and advertised to PE1.

Layer 2 Load Balancing Coexistence

The load balance method that is required in the Layer 2 VPN is different from the method that is used for Layer 3 VPN. Layer 3 VPN and Layer 2 VPN forwarding is performed independently using two different types of adjacencies. The forwarding is not impacted by using a different method of load balancing for the Layer 2 VPN.

Note Load balancing is not supported at the ingress PE for Layer 2 VPNs

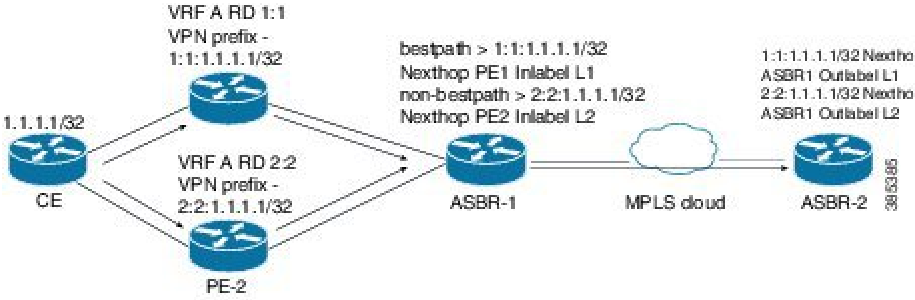
BGP VPNv4 Multipath

BGP VPNv4 Multipath feature helps to achieve Equal Cost Multi-Path (ECMP) for traffic flowing from an Autonomous System Border Router (ASBR) towards the Provider Edge (PE) device in an Multi-Protocol Label Switching (MPLS) cloud network by using a lower number of prefixes and MPLS labels. This feature configures the maximum number of multipaths for both eBGP and iBGP paths. This feature can be configured on PE devices and Route Reflectors in an MPLS topology.

Consider a scenario in which a dual homed Customer Edge (CE) device is connected to 2 PE devices and you have to utilize both the PE devices for traffic flow from ASBR-2 to the CE device.

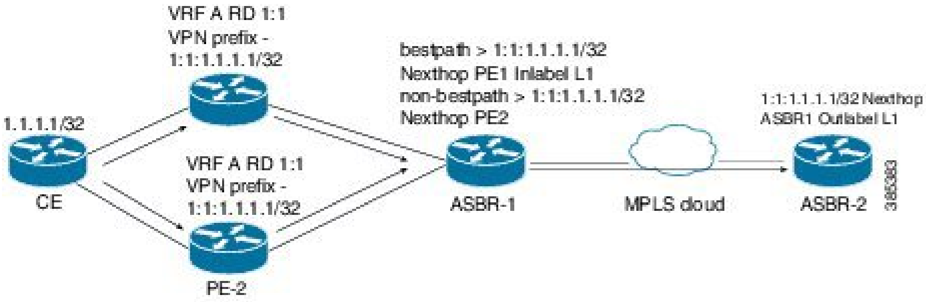
Currently, as shown in following figure, Virtual Routing and Forwarding (VRF) on each PE is configured using separate Route Distinguishers (RD). The CE device generates a BGP IPv4 prefix. The PE devices are configured with 2 separate RDs and generate two different VPN-IPv4 prefixes for the BGP IPv4 prefix sent by the CE device. ASBR-1 receives both the VPN-IPv4 prefixes and adds them to the routing table. ASBR-1 allocates Inter-AS option-B labels, Inlabel L1 and Inlabel L2, to both the VPN routes and then advertises both VPN routes to ASBR-2. To use both PE devices to maintain traffic flow, ASBR-1 has to utilize two Inter-AS option-B labels and two prefixes which limits the scale that can be supported.

Figure 6: Virtual Routing and Forwarding (VRF) on each PE configured using separate Route Distinguishers



Using the BGP VPN Multipath feature, as shown in Figure 22-4, you can enable the VRF on both PE devices to use the same RD. In such a scenario, ASBR-1 receives the same prefix from both the PE devices. ASBR-1 allocates only one Inter-AS option-B label, Inlabel L1, to the received prefix and advertises the VPN route to ASBR-2. In this case, the scale is enhanced as traffic flow using both PE devices is established with only one prefix and label on ASBR-1.

Figure 7: Enabling the VRF on both PE devices to use the same RD



BGP Cost Community

The BGP cost community is a nontransitive extended community attribute that is passed to iBGP and confederation peers but not to eBGP peers. (A confederation is a group of iBGP peers that use the same autonomous system number to communicate to external networks.) The BGP cost community attributes includes a cost community ID and a cost value. You can customize the BGP best path selection process for a local autonomous system or confederation by configuring the BGP cost community attribute. You configure the cost community attribute in a route map with a community ID and cost value. BGP prefers the path with the lowest community ID, or for identical community IDs, BGP prefers the path with the lowest cost value in the BGP cost community attribute.

BGP uses the best path selection process to determine which path is the best where multiple paths to the same destination are available. You can assign a preference to a specific path when multiple equal cost paths are available.

Since the administrative distance of iBGP is worse than the distance of most Interior Gateway Protocols (IGPs), the unicast Routing Information Base (RIB) may apply the same BGP cost community compare algorithm before using the normal distance or metric comparisons of the protocol or route. VPN routes that are learned through iBGP can be preferred over locally learned IGP routes.

The cost extended community attribute is propagated to iBGP peers when an extended community exchange is enabled.

How the BGP Cost Community Influences the Best Path Selection Process

The cost community attribute influences the BGP best path selection process at the point of insertion (POI). The POI follows the IGP metric comparison. When BGP receives multiple paths to the same destination, it uses the best path selection process to determine which path is the best path. BGP automatically makes the decision and installs the best path into the routing table. The POI allows you to assign a preference to a specific path when multiple equal cost paths are available. If the POI is not valid for local best path selection, the cost community attribute is silently ignored.

You can configure multiple paths with the cost community attribute for the same POI. The path with the lowest cost community ID is considered first. All of the cost community paths for a specific POI are considered, starting with the one with the lowest cost community ID. Paths that do not contain the cost community (for the POI and community ID being evaluated) are assigned with the default community cost value.

Applying the cost community attribute at the POI allows you to assign a value to a path originated or learned by a peer in any part of the local autonomous system or confederation. The router can use the cost community as a tie breaker during the best path selection process. You can configure multiple instances of the cost community for separate equal cost paths within the same autonomous system or confederation. For example, you can apply a lower cost community value to a specific exit path in a network with multiple equal cost exits points, and the BGP best path selection process prefers that specific exit path.

Cost Community and EIGRP PE-CE with Back-Door Links

BGP prefers back-door links in an Enhanced Interior Gateway Protocol (EIGRP) Layer 3 VPN topology if the back-door link is learned first. A back-door link, or a route, is a connection that is configured outside of the Layer 3 VPN between a remote and main site.

The pre-best path point of insertion (POI) in the BGP cost community supports mixed EIGRP Layer 3 VPN network topologies that contain VPN and back-door links. This POI is applied automatically to EIGRP routes that are redistributed into BGP. The pre-best path POI carries the EIGRP route type and metric. This POI influences the best-path calculation process by influencing BGP to consider this POI before any other comparison step.

Prerequisites for MPLS Layer 3 VPN Load Balancing

MPLS Layer 3 VPN load balancing has the following prerequisites:

- You must enable the MPLS and L3VPN features.
- You must install the correct license for MPLS.

Guidelines and Limitations for MPLS Layer 3 VPN Load Balancing

MPLS Layer 3 VPN load balancing has the following configuration guidelines and limitations:

- MPLS Layer 3 VPN load balancing is supported on Cisco Nexus 3600 platform switches.
- If you place a router behind a route reflector and it is connected to multihomed sites, the router will not be advertised unless separate VRFs with different RDs are configured for each VRF.
- Each IP routing table entry for a BGP prefix that has multiple iBGP paths uses additional memory. We recommend that you do not use this feature on a router with a low amount of available memory or when it is carrying a full Internet routing table.
- You should not ignore the BGP cost community when a back-door link is present and EIGRP is the PE-CE routing protocol.
- A maximum of 16K VPN prefixes is supported on Cisco Nexus 3600 platform switches with N3K-C3636C-R and N3K-C36180YC-R line cards.
- 4K VRFs are supported.

Default Settings for MPLS Layer 3 VPN Load Balancing

The following table lists the default settings for MPLS Layer 3 VPN load balancing parameters.

Table 6: Default MPLS Layer 3 VPN Load Balancing Parameters

Parameters	Default
Layer 3 VPN feature	Disabled
BGP cost community ID	128
BGP cost community cost	2147483647
maximum multipaths	1
BGP VPNv4 Multipath	Disabled

Configuring MPLS Layer 3 VPN Load Balancing

Configuring BGP Load Balancing for eBGP and iBGP

You can configure a Layer 3 VPN load balancing for an eBGP or iBGP network.

SUMMARY STEPS

1. **configure terminal**
2. **feature-set mpls**
3. **feature mpls l3vpn**
4. **feature bgp**
5. **router bgp** *as - number*
6. **bestpath cost-community ignore remote-as** *as-number*
7. **address-family { ipv4 | ipv6 } unicast**
8. **maximum-paths** [**bgp**] *number-of-paths*
9. **show running-config bgp**
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

	Command or Action	Purpose
Step 2	**feature-set mpls** **Example:** `switch(config)# feature-set mpls`	Enables the MPLS feature-set.
Step 3	**feature mpls l3vpn** **Example:** `switch(config)# feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature.

Step 4	**feature bgp**
	Example:
	`switch(config)# feature bgp`
	`switch(config)#`
		Enables the BGP feature.

Step 5	**router bgp** *as - number*
	Example:
	`switch(config)# router bgp 1.1`
	`switch(config-router)#`
		Configures a BGP routing process and enters router configuration mode.
		The *as-number* argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 6	**bestpath cost-community ignore remote-as** *as-number* **Example:** `switch(config-router)# bestpath cost-community ignore#`	(Optional) Ignores the cost community for BGP bestpath calculations.

Step 7	**address-family { ipv4 | ipv6 } unicast**
	Example:
	`switch(config-router)# address-family ipv4 unicast`
	`switch(config-router-af)#`
		Enters address family configuration mode for configuring IP routing sessions.

Step 8	**maximum-paths** [**bgp**] *number-of-paths* **Example:** `switch(config-router-af)# maximum-paths 4`	Configures the maximum number of multipaths allowed. Use the ibgp keyword to configure **iBGP** load balancing. The range is from 1 to 16.
Step 9	**show running-config bgp** **Example:** `switch(config-router-vrf-neighbor-af)# show running-config bgp`	(Optional) Displays the running configuration for BGP.
Step 10	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring BGPv4 Multipath

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **router bgp** *as - number*
4. **address-family vpnv4 unicast**
5. **maximum-paths eibgp** *parallel-paths*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp** **Example:** `switch(config)# feature bgp`	Enables the BGP feature.

Step 3	**router bgp** *as - number*
	Example:
	`switch(config)# router bgp 2`
	`switch(config-router)#`
		Assigns an autonomous system (AS) number to a router and enter the router BGP configuration mode.

Step 4	**address-family vpnv4 unicast**
	Example:
	`switch(config-router)# address-family vpnv4 unicast`
	`switch(config-router-af)#`
		Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 address prefixes.

Step 5	**maximum-paths eibgp** *parallel-paths* **Example:** `switch(config-router-af)# maximum-paths eibgp 3`	Specifies the maximum number of BGP VPNv4 multipaths for both eBGP and iBGP paths. The range is from 1 to 32.

Configuration Examples for MPLS Layer 3 VPN Load Balancing

Example: MPLS Layer 3 VPN Load Balancing

The following example shows how to configure iBGP load balancing:

```
 configure terminal
feature-set mpls
```

```
feature mpls l3vpn
feature bgp
router bgp 1.1
bestpath cost-community ignore
address-family ipv6 unicast
maximum-paths ibgp 4
```

Example: BGP VPNv4 Multipath

The following example shows how to configure a maximum of 3 BGP VPNv4 multipaths:

```
 configure terminal
router bgp 100
address-family vpnv4 unicast
maximum-paths eibgp 3
```

Example: MPLS Layer 3 VPN Cost Community

The following example shows how to configure the BGP cost community:

```
 configure terminal
feature-set mpls
feature mpls l3vpn
feature bgp
route-map CostMap permit
set extcommunity cost 1 100
router bgp 1.1
router-id 192.0.2.255
neighbor 192.0.2.1 remote-as 1.1
address-family vpnv4 unicast
send-community extended
route-map CostMap in
```

CHAPTER 7

Configuring MPLS QoS

This chapter describes how to configure Quality of Service for Multiprotocol Label Switching (MPLS) Layer 3 virtual private networks (VPNs).

About MPLS Quality of Service (QoS)

MPLS QoS enables you to provide differentiated types of service across an MPLS network. Differentiated types of service satisfy a range of requirements by supplying the service specified for each packet. QoS allows you to classify the network traffic, police and prioritize the traffic flow, and provide congestion avoidance.

This section includes the following topics:

MPLS QoS Terminology

This section defines some MPLS QoS terminology:

- Classification is the process that selects the traffic to be marked. Classification matches traffic with the selection criteria into multiple priority levels or classes of service. Traffic classification is the primary component of class-based QoS provisioning. The switch makes classification decisions based on the EXP bits in the topmost label of the received MPLS packets (after a policy is installed).
- Differentiated Services Code Point (DSCP):
    - Is the first six bits of the ToS byte in the IP header.
    - Only present in an IP packet.
    - Can be present in an IPv4 or an IPv6 packet.
    - Is the first 6 bits of the 8-bit Traffic Class octet in the IPv6 header.

- E-LSP is a label switched path (LSP) on which nodes infer the QoS treatment for MPLS packets exclusively from the experimental (EXP) bits in the MPLS header. Because the QoS treatment is inferred from the EXP (both class and drop precedence), several classes of traffic can be multiplexed onto a single LSP (use the same label). A single LSP can support up to eight classes of traffic because the EXP field is a 3-bit field.
- EXP bits define the QoS treatment (per-hop behavior) that a node should give to a packet. It is the equivalent of the DiffServ Code Point (DSCP) in the IP network. A DSCP defines a class and drop precedence. The EXP bits are generally used to carry all the information encoded in the IP DSCP. In some cases, however, the EXP bits are used exclusively to encode the dropping precedence.
- Marking is the process of setting a Layer 3 DSCP value in a packet. Marking is also the process of choosing different values for the MPLS EXP field to mark packets so that they have the priority that they require during periods of congestion.
- MPLS Experimental Field: Setting the MPLS experimental (EXP) field value satisfies the requirement of operators who do not want the value of the IP precedence field modified within IP packets transported through their networks. By choosing different values for the MPLS EXP field, you can mark packets so that packets have the priority that they require during periods of congestion. By default, the three most significant bits of the DSCP are copied into the MPLS EXP field during imposition. You can mark the MPLS EXP bits with an MPLS QoS policy.

MPLS QoS Features

QoS enables a network to provide improved service to selected network traffic. This section explains the following MPLS QoS features, which are supported in an MPLS network:

MPLS Experimental Field

Setting the MPLS experimental (EXP) field value satisfies the requirement of service providers who do not want the value of the IP precedence field modified within IP packets transported through their networks.

By choosing different values for the MPLS EXP field, you can mark packets so that packets have the priority that they require during periods of congestion.

By default, the IP precedence value is copied into the MPLS EXP field during imposition. You can mark the MPLS EXP bits with an MPLS QoS policy.

Trust

For received Layer 3 MPLS packets, the PFC usually trusts the EXP value in the received topmost label. None of the following have any effect on MPLS packets:

- Interface trust state
- Port CoS value
- Policy-map trust command

For received Layer 2 MPLS packets, the PFC can either trust the EXP value in the received topmost label or apply port trust or policy trust to the MPLS packets for CoS and egress queueing purposes.

Classification

Classification is the process that selects the traffic to be marked. Classification accomplishes this by partitioning traffic into multiple priority levels, or classes of service. Traffic classification is the primary component of class-based QoS provisioning.

Policing and Marking

Policing causes traffic that exceeds the configured rate to be discarded or marked down to a higher drop precedence. Marking is a way to identify packet flows to differentiate them. Packet marking allows you to partition your network into multiple priority levels or classes of service.

The MPLS QoS policing and marking features that you can implement depend on the received traffic type and the forwarding operation applied to the traffic.

Guidelines and Limitations for MPLS QoS

MPLS Quality of Service (QoS) has the following configuration guidelines and limitations:

- When setting the QoS policy, the **topmost** keyword in the **set mpls experimental imposition** CLI is not supported.
- MPLS QoS supports MAX 4 Label stack for imposition.
- MPLS QoS does not support remarking based on policing.
- L3 EVPN egress node - policing is not supported on a system level mpls-in-policy.
- Egress QoS classification based on MPLS EXP is not supported.
- EXP labels are only set for newly pushed or swapped labels. The EXP in the inner labels remains unchanged.
- On the Label Edge Router (LER), policy match on EXP is not supported. Inner DSCP can be used to match the packets.
- Interface policy cannot be used to classify MPLS L3 EVPN packets on the Egress Label Edge Router (LER).System level MPLS-Default policy is used to classify the traffic.
- Explicit Congestion Notification (ECN) Marking is not supported on the label switching router transit node.
- Only the default QoS Service template is supported for the MPLS handoff in Cisco NX-OS Release 9.3(1). You cannot set the EXP labels on the MPLS.

Configuring MPLS QoS

Note Be aware that the Cisco NX-OS commands for this feature may differ from those commands used in Cisco IOS.

Configuring MPLS Ingress Label Switched Router

To configure MPLS Ingress label switched router, perform the following:

MPLS Ingress LSR Classification

To match the value of the Differentiated Services Code Point (DSCP) field, use the **match dscp** command in QoS policy-map class configuration mode. To disable the setting, use the **no** form of this command.

Note Default entries are programmed to match on DSCP and mark EXP when no ingress QoS policy is configured (Uniform mode behavior at encap).

Before you begin

- You must enable MPLS configuration.
- Ensure that you are in the correct VDC (or use the switch to vdc command).

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **class-map type qos** *class-map-name*
3. [**no**] **match** [**not**] **dscp** *dscp-list*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **class-map type qos** *class-map-name*
	Example:
	`switch(config)# class-map type qos Class1`
	`switch(config-cmap-qos)#`
		Defines a class map, and enters class-map configuration mode.

Step 3	[**no**] **match** [**not**] **dscp** *dscp-list* **Example:** `switch(config)# switch(config-cmap-qos)# match dscp 2-4`	List of DSCP values. Specifies that the packets should be matched (or not) on the DSCP label in the MPLS header as follows: • **dscp-list**—The list can contain values and ranges. Values can range from 0 to 63.

Configuring MPLS Ingress Policing and Marking

To configure a policy-map value and set the EXP value on all imposed label entries, use the **set mpls experimental imposition** command in QoS policy-map class configuration mode. To disable the setting, use the **no** form of this command.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **policy-map type qos** *policy-map-name*
3. **class** *class-name*
4. **set mpls experimental imposition** *exp_imposition_name*
5. **set qos-group** *group-number*
6. **police cir** *burst-in-msec* **bc** *conform-burst-in-msec* **conform-action** *conform-action* **violate-action** *violate-action*
7. **interface** *type slot/port*
8. **service-policy type qos input** *policy-map-name*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **policy-map type qos** *policy-map-name*
	Example:
	`switch(config)# policy-map type qos pmap1`
	`switch(config-pmap-qos)#`
		Defines a policy map, and enters policy-map configuration mode.

Step 3	**class** *class-name*
	Example:
	`switch(config-pmap-qos)# class Class1`
		Names the class-map.

Step 4	**set mpls experimental imposition** *exp_imposition_name* **Example:** `switch(config)# switch(config-pmap-qos)# set mpls experimental imposition 2`	MPLS experimental (EXP) values. Value range from 0 to 7.
Step 5	**set qos-group** *group-number* **Example:** `switch(config-cmap-qos)# set qos-group 1`	Identifies the qos-group number.
Step 6	**police cir** *burst-in-msec* **bc** *conform-burst-in-msec* **conform-action** *conform-action* **violate-action** *violate-action*	Defines a policer for classified traffic in policy-map class configuration mode.

	Command or Action	Purpose
	Example: `switch(config-pmap-qos)# police cir 100 mbps bc 200 ms conform transmit violate drop`	

Step 7	**interface** *type slot/port*
	Example:
	`switch(config)# interface ethernet 2/2`
	`switch(config-if)#`
		Enters the interface configuration mode for the specified input interface, output interface, virtual circuit (VC), or a VC that will be used as the service policy for the interface or VC.

Step 8	**service-policy type qos input** *policy-map-name*
	Example:
	`switch(config-if)# service-policy type qos input pmap1`
	`switch(config-if)#`
		Attaches a policy map to an input interface, a virtual circuit (VC), an output interface, or a VC that will be used as the service policy for the interface or VC.

Configuring MPLS Transit Label Switching Router

To configure MPLS Transit Label Switching Routers, perform the following:

MPLS Transit LSR Classification

To map the value of the MPLS EXP field on all imposed label entries, use the **set mpls experimental topmost** command in QoS policy-map class configuration mode. To disable the setting, use the **no** form of this command.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **class-map type qos** *class-map-name*
3. [**no**] **match** [**not**] **mpls experimental topmost** *exp-list*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **class-map type qos** *class-map-name*
	Example:
	`switch(config)# class-map type qos Class1`
	`switch(config-cmap-qos)#`
		Defines a class map, and enters class-map configuration mode.

Step 3	[**no**] **match** [**not**] **mpls experimental topmost** *exp-list* **Example:** `switch(config)# switch(config-cmap-qos)# match mpls experimental topmost 2, 4-7`	List of MPLS experimental (EXP) values. Specifies that the packets should be matched (or not) on the 3-bit EXP field in the outermost (topmost) MPLS label in the MPLS header as follows:

	Command or Action	Purpose
		• **exp-list**—The list can contain values and ranges. Values can range from 0 to 7.

Configuring MPLS Transit Policing and Marking

To configure a policy-map value and set the EXP value on all imposed label entries, use the **service-policy type qos input pmap1** command in interface configuration mode. To disable the setting, use the **no** form of this command.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **policy-map type qos** *policy-map-name*
3. **class** *class-name*
4. **set mpls experimental imposition** *exp_imposition_name*
5. **set qos-group** *group-number*
6. **police cir** *burst-in-msec* **bc** *conform-burst-in-msec* **conform-action** *conform-action* **violate-action** *violate-action*
7. **interface** *type slot/port*
8. **service-policy type qos input** *policy-map-name*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **policy-map type qos** *policy-map-name*
	Example:
	`switch(config)# policy-map type qos Class1`
	`switch(config-pmap-qos)#`
		Defines a policy map, and enters policy-map configuration mode.

Step 3	**class** *class-name*
	Example:
	`switch(config-pmap-qos)# class Class1`
		Names the class-map.

Step 4	**set mpls experimental imposition** *exp_imposition_name* **Example:** `switch(config)# switch(config-pmap-qos)# set mpls experimental imposition 2`	MPLS experimental (EXP) values. Value range from 0 to 7.
Step 5	**set qos-group** *group-number* **Example:**	Identifies the qos-group number.

	Command or Action	Purpose
	`switch(config-pmap-qos)# set qos-group 1`	
Step 6	**police cir** *burst-in-msec* **bc** *conform-burst-in-msec* **conform-action** *conform-action* **violate-action** *violate-action* **Example:** `switch(config-pmap-qos)# police cir 100 mbps bc 200 ms conform transmit violate drop`	Defines a policer for classified traffic in policy-map class configuration mode. • violate-action - **drop** is the only supported keyword for Transit LSR

Step 7	**interface** *type slot/port*
	Example:
	`switch(config)# interface ethernet 2/2`
	`switch(config-if)#`
		Enters the interface configuration mode for the specified input interface, output interface, virtual circuit (VC), or a VC that will be used as the service policy for the interface or VC.

Step 8	**service-policy type qos input** *policy-map-name*
	Example:
	`switch(config-if)# service-policy type qos input pmap1`
	`switch(config-if)#`
		Attaches a policy map to an input interface, a virtual circuit (VC), an output interface, or a VC that is used as the service policy for the interface or VC.

Configuring MPLS Egress Label Switching Router

To configure MPLS Egress label switched router, perform the following:

MPLS Egress LSR Classification

To classify the incoming SR MPLS traffic to egress queue, use the match on Differentiated Services Code Point (DSCP) field.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **class-map type qos** *class-map-name*
3. [**no**] **match** [**not**] **dscp** *dscp-list*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **class-map type qos** *class-map-name*
	Example:
	`switch(config)# class-map type qos Class1`
	`switch(config-cmap-qos)#`
		Defines a class map, and enters class-map configuration mode.

	Command or Action	Purpose
Step 3	[**no**] **match** [**not**] **dscp** *dscp-list* **Example:** `switch(config)# switch(config-cmap-qos)# match dscp 2-4`	List of DSCP values. Specifies that the packets should be matched (or not) on the DSCP label in the MPLS header as follows: • **dscp-list**—The list can contain values and ranges. Values can range from 0 to 63.

MPLS Egress LSR Classification - Default Policy Template

To classify the incoming traffic to the egress queue of an EVPN tunnel, use the default **default-mpls-in-policy** command at the system level. To disable the setting, use the **no** form of this command.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **system qos**
3. [**no**] **service-policy type qos input default-mpls-in-policy**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **system qos**
	Example:
	`switch(config)# system qos`
	`switch(config-sys-qos)#`
		Enters system QoS configuration mode.

Step 3	[**no**] **service-policy type qos input default-mpls-in-policy** **Example:** `switch(config-sys-qos)# service-policy type qos input default-mpls-in-policy`	Specifies the “default-mpls-in-policy” at the system level to match on the incoming SR L3 EVPN MPLS traffic.

The following is the default MPLS in policy template configured with the **service-policy type qos input default-mpls-in-policy** command.

```
policy-map type qos default-mpls-in-policy
    class  c-dflt-mpls-qosgrp1
      set qos-group 1
    class  c-dflt-mpls-qosgrp2
      set qos-group 2
    class  c-dflt-mpls-qosgrp3
      set qos-group 3
    class  c-dflt-mpls-qosgrp4
      set qos-group 4
    class  c-dflt-mpls-qosgrp5
```

```
      set qos-group 5
    class  c-dflt-mpls-qosgrp6
      set qos-group 6
    class  c-dflt-mpls-qosgrp7
      set qos-group 7
    class  class-default
      set qos-group 0

class-map type qos match-any c-dflt-mpls-qosgrp1
  Description: This is an ingress default qos class-map that classify traffic with prec 1
  match precedence 1

class-map type qos match-any c-dflt-mpls-qosgrp2
  Description: This is an ingress default qos class-map that classify traffic with prec 2
  match precedence 2

class-map type qos match-any c-dflt-mpls-qosgrp3
  Description: This is an ingress default qos class-map that classify traffic with prec 3
  match precedence 3

class-map type qos match-any c-dflt-mpls-qosgrp4
  Description: This is an ingress default qos class-map that classify traffic with prec 4
  match precedence 4

class-map type qos match-any c-dflt-mpls-qosgrp5
  Description: This is an ingress default qos class-map that classify traffic with prec 5
  match precedence 5

class-map type qos match-any c-dflt-mpls-qosgrp6
  Description: This is an ingress default qos class-map that classify traffic with prec 6
  match precedence 6

class-map type qos match-any c-dflt-mpls-qosgrp7
  Description: This is an ingress default qos class-map that classify traffic with prec 7
  match precedence 7
```

Custom MPLS-in-Policy Mapping

You can override the queue mapping of incoming traffic by editing a local copy of the template provided. The system matching is always based on precedence, and requires the “mpls-in-policy” string to be part of the policy name. Marking with QoS is supported. Set can be qos-group, vlan-cos, or both.

```
class-map type qos match-all prec-1
      match precedence 1
    class-map type qos match-all prec-2
      match precedence 2

policy-map type qos test-mpls-in-policy
    class  prec-1
      set qos-group 3
    class  prec-2
      set qos-group 4
system qos
  service-policy type qos input test-mpls-in-policy
```

Note Classification based on Precedence is only supported and Marking is not supported on system level mpls-in-policy.

Configuring MPLS Egress LSR - Policing and Marking

To configure and apply a policy-map with policer config, use the **service-policy type qos input pmap1** command in interface configuration mode. To disable the setting, use the **no** form of this command.

> **Note** Policing is not supported for SR L3 EVPN MPLS traffic

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **policy-map type qos** *class-map-name*
3. **policy** *policy-name*
4. **set dscp** *dscp-value*
5. **set qos-group** *group-number*
6. [**no**] **police cir** *burst-in-msec* **bc** *conform-burst-in-msec* **conform-action** *conform-action* **violate-action** *violate-action*
7. **interface** *type slot/port*
8. [**no**] **service-policy type qos input** *policy-map-name*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	[**no**] **policy-map type qos** *class-map-name*
	Example:
	`switch(config)# policy-map type qos Class1`
	`switch(config-pmap-qos)#`
		Defines a class map, and enters class-map configuration mode.

Step 3	**policy** *policy-name* **Example:** `switch(config-pmap-qos)# class Class1`	Names the class-map.
Step 4	**set dscp** *dscp-value* **Example:** `switch(config-pmap-qos)# set dscp 4`	Identifies the dscp value.
Step 5	**set qos-group** *group-number* **Example:** `switch(config-pmap-qos)# set qos-group 1`	Identifies the qos-group number.

	Command or Action	Purpose
Step 6	[**no**] **police cir** *burst-in-msec* **bc** *conform-burst-in-msec* **conform-action** *conform-action* **violate-action** *violate-action* **Example:** `switch(config-pmap-qos)# police cir 100 mbps bc 200 ms conform transmit violate drop`	Defines a policer for classified traffic in policy-map class configuration mode.

Step 7	**interface** *type slot/port*
	Example:
	`switch(config)# interface ethernet 2/2`
	`switch(config-if)#`
		Enters the interface configuration mode for the specified interface.

Step 8	[**no**] **service-policy type qos input** *policy-map-name*
	Example:
	`switch(config-if)# service-policy type qos input pmap1`
	`switch(config-if)#`
		Attaches a policy map to an input interface, a virtual circuit (VC), an output interface, or a VC that will be used as the service policy for the interface or VC.

About Traffic Queuing

Traffic queuing is the ordering of packets and applies to both input and output of data. Device modules can support multiple queues, which you can use to control the sequencing of packets in different traffic classes. You can also set weighted random early detection (WRED) and taildrop thresholds. The device drops packets only when the configured thresholds are exceeded.

Configuring QoS Traffic Queuing

To set the output queue, use the **set qos-group** command in policy map configuration mode. To disable the setting, use the **no** form of this command.

SUMMARY STEPS

1. **configure terminal**
2. [**no**] **policy-map type qos** *class-map-name*
3. **class** *class-name*
4. **set qos-group** *qos_group_number*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

	Command or Action	Purpose

Step 2	[**no**] **policy-map type qos** *class-map-name*
	Example:
	`switch(config)# class-map type qos Class1`
	`switch(config-cmap-qos)#`
		Defines a class map, and enters class-map configuration mode.

Step 3	**class** *class-name*
	Example:
	`switch(config-cmap-qos)# class Class1`
		Names the class-map.

Step 4	**set qos-group** *qos_group_number* **Example:** `switch(config-pmap-c-qos)# set qos-group`	Applies queueing parameters for the named QoS group in policy map. Value range from 0 to 7.

Verifying MPLS QoS

To display the MPLS QoS configuration, perform the following task:

Command	Description
show hardware internal forwarding table utilization	Displays information about the MAX label entries and Used label entries.
show class-map	Displays the interface class mapping statistics.
show policy-map system type qos input	Displays the cumulative statistics that show the packets matched for every class for all the interfaces (only for the EVPN tunnel case). For more information, see the sample output following this table.
show policy-map type qos interface interface	Displays the statistics that show the packets matched for every class on that interface in the given direction.
show policy-map type qos <pmap name>	Displays the service policy maps configured on the interfaces.
show queuing interface	Displays the queuing information of interfaces.

The following example displays the cumulative statistics that show the packets matched for every class for all the interfaces (only for the EVPN tunnel case).

```
switch# show policy-map system type qos input


  Service-policy (qos) input:   default-mpls-in-policy

    Class-map (qos):   c-dflt-mpls-qosgrp1 (match-any)

     Slot 3
        2775483 packets
     Aggregate forwarded :
        2775483 packets
      Match: precedence 1
      set qos-group 1

    Class-map (qos):   c-dflt-mpls-qosgrp2 (match-any)

     Slot 3
        2775549 packets
     Aggregate forwarded :
        2775549 packets
      Match: precedence 2
      set qos-group 2

    Class-map (qos):   c-dflt-mpls-qosgrp3 (match-any)

     Slot 2
        2777189 packets
     Aggregate forwarded :
        2777189 packets
      Match: precedence 3
      set qos-group 3

    Class-map (qos):   c-dflt-mpls-qosgrp4 (match-any)

     Slot 3
        2775688 packets
     Aggregate forwarded :
        2775688 packets
      Match: precedence 4
      set qos-group 4

    Class-map (qos):   c-dflt-mpls-qosgrp5 (match-any)

     Slot 3
        2775756 packets
     Aggregate forwarded :
        2775756 packets
      Match: precedence 5
      set qos-group 5

    Class-map (qos):   c-dflt-mpls-qosgrp6 (match-any)

     Slot 3
        2775824 packets
     Aggregate forwarded :
        2775824 packets
      Match: precedence 6
      set qos-group 6

    Class-map (qos):   c-dflt-mpls-qosgrp7 (match-any)

     Slot 3
        2775892 packets
     Aggregate forwarded :
```

```
    2775892 packets
  Match: precedence 7
  set qos-group 7

Class-map (qos):   class-default (match-any)

 Slot 3
    2775962 packets
 Aggregate forwarded :
    2775962 packets
  set qos-group 0
```

CHAPTER 8

Configuring MVPNs

This chapter contains information on how to configure multicast virtual private networks (MVPNs)

About MVPNs

The multicast virtual private networks (MVPNs) feature allows you to support multicast connectivity over Layer 3 VPN. IP multicast is used to stream video, voice, and data to an VPN network core.

Historically, point-to-point tunnels were the only way to connect through an enterprise or service provider network. Although such tunneled networks had scalability issues, they were the only means of passing IP multicast traffic through a virtual private network (VPN). Because Layer 3 VPNs support only unicast traffic connectivity, deploying with a Layer 3 VPN allows operators to offer both unicast and multicast connectivity to Layer 3 VPN customers

MVPNs allows you to configure and support multicast traffic in an MVPN environment. MVPNs support routing and forwarding of multicast packets for each individual virtual routing and forwarding (VRF) instance, and it also provides a mechanism to transport VPN multicast packets across the enterprise or service provider backbone. IP multicast is used to stream video, voice, and data to a VPN network core.

A VPN allows network connectivity across a shared infrastructure, such as an Internet Service Provider (ISP). Its function is to provide the same policies and performance as a private network at a reduced cost of ownership.

MVPNs allow an enterprise to transparently interconnect its private network across the network backbone. Using MVPNs to interconnect an enterprise network does not change the way that an enterprise network is administered and it does not change general enterprise connectivity.

MVPN Routing and Forwarding and Multicast Domains

MVPNs introduce multicast routing information to the VPN routing and forwarding table. When a provider edge (PE) router receives multicast data or control packets from a customer edge (CE) router, the router forwards the data or control packets according to the information in the MVPN routing and forwarding (MVRF).

A set of MVRFs that can send multicast traffic to each other constitutes a multicast domain. For example, the multicast domain for a customer that wanted to send certain types of multicast traffic to all global employees would consist of all CE routers that are associated with that enterprise.

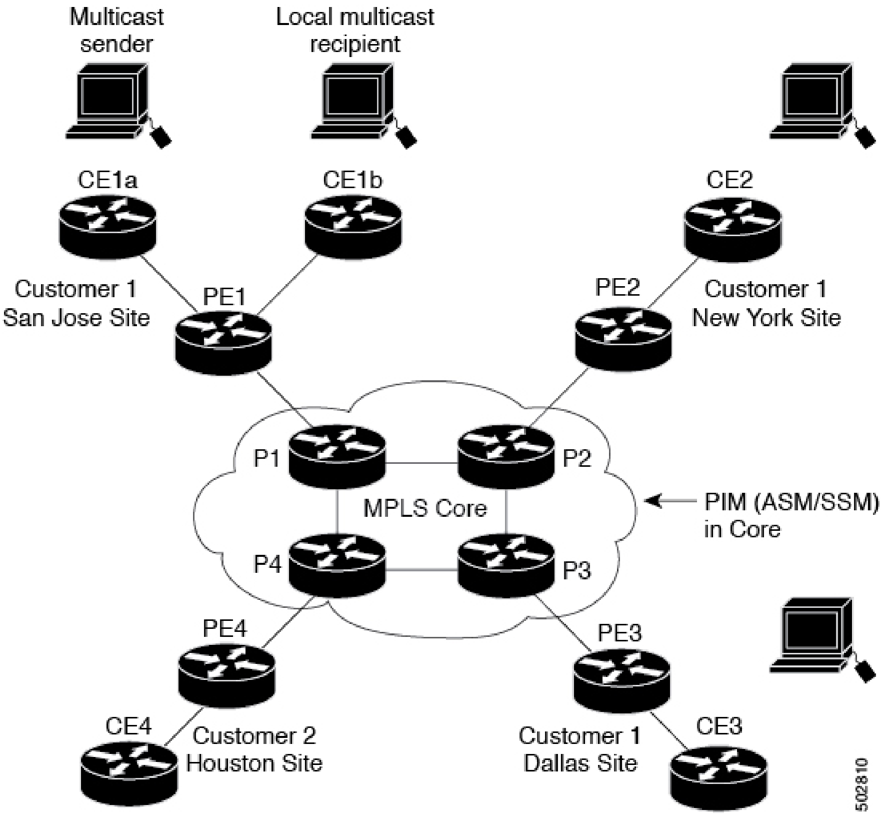
Multicast Distribution Tree

MVPNs establish a static default multicast distribution tree (MDT) for each multicast domain. The default MDT defines the path used by PE routers to send multicast data and control messages to every other PE router in the multicast domain.

MVPNs also support the dynamic creation of MDTs for high-bandwidth transmission. Data MDTs are intended for high-bandwidth sources such as full-motion video inside the VPN to ensure optimal traffic forwarding in the VPN core.

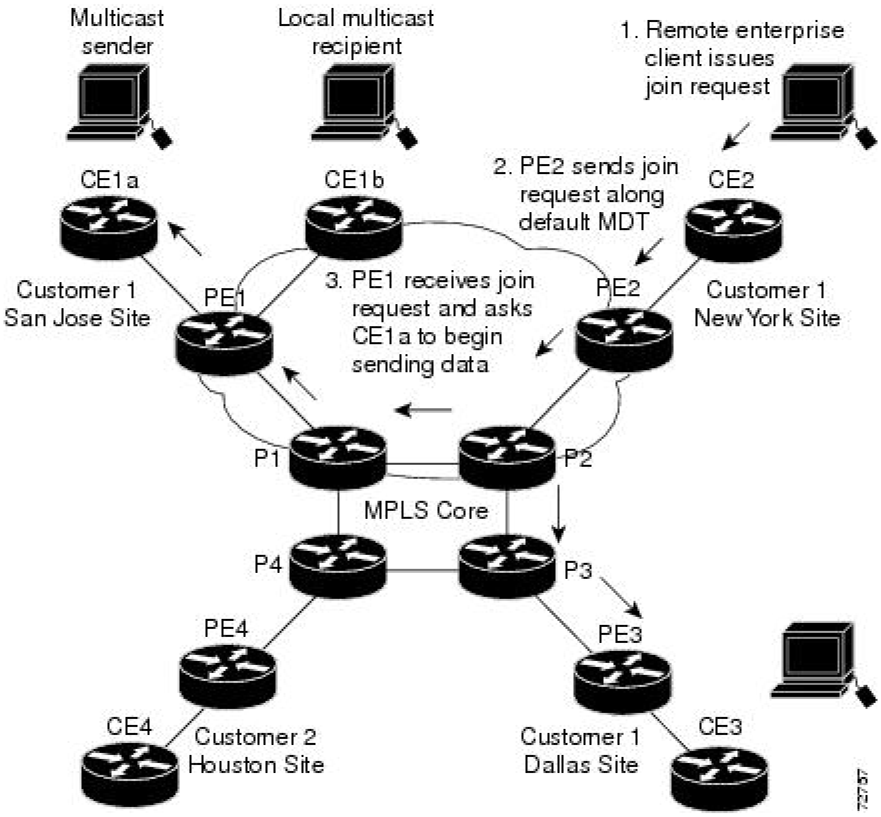
In the following example, a service provider has a multicast customer with offices in San Jose, New York, and Dallas. A one-way multicast presentation is occurring in San Jose. The service provider network supports all three sites that are associated with this customer, in addition to the Houston site of a different enterprise customer. The default MDT for the enterprise customer consists of provider routers P1, P2, and P3 and their associated PE routers. PE4 is not part of the default MDT, because it is associated with a different customer. The following figure shows that no data flows along the default MDT, because no one outside of San Jose has joined the multicast.

Figure 8: Default Multicast Distribution Tree Overview



An employee in New York joins the multicast session. The PE router that is associated with the New York site sends a join request that flows across the default MDT for the multicast domain of the customer. PE1, the PE router that is associated with the multicast session source, receives the request. The following figure depicts that the PE router forwards the request to the CE router that is associated with the multicast source (CE1a).

Figure 9: Initializing the Data MDT


Multicast sender
Local multicast recipient
1. Remote enterprise client issues join request
2. PE2 sends join request along default MDT
CE1a
CE1b
CE2
Customer 1 San Jose Site
PE1
3. PE1 receives join request and asks CE1a to begin sending data
PE2
Customer 1 New York Site
P1
P2
MPLS Core
P4
P3
PE4
PE3
CE4
Customer 2 Houston Site
Customer 1 Dallas Site
CE3
72757

The CE router (CE1a) begins to send the multicast data to the associated PE router (PE1), which sends the multicast data along the default MDT. PE1 creates a data MDT, sends a message to all routers using the default MDT that contains information about the data MDT, and, three seconds later, begins sending the multicast data for that particular stream using the data MDT. Only PE2 has interested receivers for this source, so only PE2 joins the data MDT and receives traffic on it. (If the data MDT had not been configured and only the default MDT had been configured, all the customer sites would have received the traffic even though they were not interested in it.) PE routers maintain a PIM relationship with other PE routers over the default MDT and a PIM relationship with its directly attached P routers.

Multicast Tunnel Interface

An MVPN routing and forwarding (MVRF), which is created per multicast domain, requires the router to create a tunnel interface from which all MVRF traffic is sourced. A multicast tunnel interface is an interface that the MVRF uses to access the multicast domain. The interface is a conduit that connects an MVRF and the global MVRF. One tunnel interface is created per MVRF.

Benefits of MVPNs

The benefits of MVPNs are as follows:

- Provides a scalable method to dynamically send information to multiple locations.
- Provides high-speed information delivery.
- Provides connectivity through a shared infrastructure.

BGP Advertisement Method - MVPN Support

When you configure the default MDT in a PIM Source Specific Multicast (PIM-SSM) environment rather than a PIM-SM environment, the receiver PE needs information about the source PE and the default MDT. This information is used to send (S, G) joins toward the source PE to build a distribution tree from the source PE without the need for a rendezvous point (RP). The source provider edge (PE) address and default MDT address are sent using the Border Gateway Protocol (BGP).

BGP MDT SAFI

BGP MDT SAFI is the BGP advertisement method that is used for MVPNs. In the current release, only IPv4 is supported. MDT SAFI has the following settings:

- AFI = 1
- SAFI = 66

In Cisco NX-OS, the source PE address and the MDT address are passed to PIM using BGP MDT SAFI updates. The Route Descriptor (RD) type has changed to RD type 0 and BGP determines the best path for the MDT updates before passing the information to PIM.

You must configure the MDT SAFI address family for BGP neighbors by using the **address-family ipv4 mdt** command. You must still enable neighbors that do not support the MDT SAFI for the MDT SAFI in the local BGP configuration. Prior to the MDT SAFI, additional BGP configuration from the VPNv4 unicast configuration was not needed to support MVPNs.

Prerequisites

MVPNs configuration has the following prerequisites:

- Ensure that you have configured MPLS and Label Distribution Protocol (LDP) in your network. All routers in the core, including the PE routers, must be able to support MPLS forwarding. VPNv4 routes are not installed by BGP if labeled paths do not exist for PE source addresses.
- Ensure that you have installed the correct license for MPLS and any other features you will be using with MPLS.

Guidelines and Limitations for MVPNs

Configuring MVPNs has the following guidelines and limitations:

- MVPNs are supported beginning with Cisco NX-OS Release 9.3(3).
- In Cisco NX-OS Release 9.3(3), MVPNs are supported only for Cisco Nexus 3600 (N3K-C36180YC-R,N3K-C3636C-R) platform switches
- Bidirectional Forwarding Detection (BFD) is not supported on the Multicast Tunnel Interface (MTI).
- By default, the BGP update source is used as the source of the MVPN tunnel. However, you can use the mdt source to override the BGP update source and provide a different source to the multicast tunnel.
- MVPN supports a maximum of 16 MDT source interfaces.
- You must configure the MDT SAFI on all routers that participate in the MVPN operations.
- Extended communities are needed for VPNv4 interior BGP (iBGP) sessions to carry the connector attribute.
- MDT MTU configuration is not supported. The maximum customer multicast packet size that can be sent over MVPN is limited by the MTU of the core interfaces. For example:
  - MTU 1500 – Customer IP packet size = 1476
  - MTU 9216 – Customer IP packet size = 9192
- Some of the MVPN multicast control packets are classified into the copp-system-p-class-l2-default CoPP policy. We recommend modifying the CoPP policy to increase the policer rate under this class if the violated count increases.
- MDT bidir-enable is not supported.
- vPCs are not supported for MVPN.
- Data MDT entries are not cached when the transit PE router does not have receivers and is connected to a CE which is a RP. The data MDT entries are cached only when a local receiver is attached to this PE router. However, there is a delay in the switchover because the entries are not pre-downloaded.
- For Date MDT, only 'immediate-switch' mode is supported. Threshold based switching is not supported.
- Sub-interface and SVI support between PE and P /PE devices is not available.
- MVPN Consistency-checker is not supported in Cisco Nexus Release 9.3(3).
- Statistics for MTI interfaces are not supported in Cisco Nexus Release 9.3(3).
- Maximum 40G multicast traffic per ASIC is supported in Cisco Nexus Release 9.3(3).

Default Settings for MVPNs

Table 7: Default MVPN Parameters

Parameters	Default
mdt default *address*	No default
mdt enforce-bgp-mdt-safi	Enabled
mdt source	No default
mdt ip pim hello-interval *interval*	30000 ms
mdt ip pim jp-interval *interval*	60000 ms
mdt default asm-use-shared-tree	Disabled

Configuring MVPNs

This chapter describes how to configure multicast virtual private networks (MVPNs) on Cisco NX-OS devices.

Note For MVPN, a new TCAM region "ing-mvpn" is used (with default size of 10). This region is carved automatically hence you need not carve it. To verify if this TCAM region is carved or not, you can use the following commands:

```
switch# show hardware access-list tcam region | i ing-mvpn
Ingress mVPN [ing-mvpn] size = 10
switch#
```

If the region is not carved due to any reason (size shows is 0), you can use the following command to carve the TCAM region to size 10 and reload the device. The TCAM is expected to be carved to size 10.

```
switch (config)# hardware access-list tcam region ing-mvpn 10
WARNING: On module 2,
WARNING: On module 4,
Warning: Please reload all linecards for the configuration to take effect
switch (config)#
```

Enabling MVPNs

Beginning with Cisco NX-OS Release 9.3(3), you can configure MVPNs on Cisco Nexus 3600 platform switches.

Before you begin

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

SUMMARY STEPS

1. **configure terminal**
2. **feature bgp**
3. **feature pim**
4. **feature mvpn**
5. **feature mpls l3vpn**
6. **feature mpls ldp**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch#configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**feature bgp** **Example:** `switch(config)#feature bgp`	Enables BGP feature and configurations.
Step 3	**feature pim** **Example:** `switch(config)#feature pim`	Enables the PIM feature.
Step 4	**feature mvpn** **Example:** `switch(config)#feature mvpn`	Enables the MVPN feature.
Step 5	**feature mpls l3vpn** **Example:** `switch(config)#feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature. This determines the unicast routes across sites.
Step 6	**feature mpls ldp** **Example:** `switch(config)#feature mpls ldp`	Enables the MPLS Label Distribution Protocol (LDP).

Enabling PIM on Interfaces

You can configure Protocol Independent Multicast (PIM) on all interfaces that are used for IP multicast. We recommend that you configure PIM sparse mode on all physical interfaces of provider edge (PE) routers that connect to the backbone. We also recommend that you configure PIM sparse mode on all loopback interfaces if they are used for BGP peering or if their IP address is used as an RP address for PIM.

Procedure

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch#configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**ip pim sparse-mode** **Example:** `switch(config)#ip pim sparse-mode`	Enables PIM sparse mode on the interface.

Configuring a Default MDT for a VRF

You can configure a default MDT for a VRF.

Before you begin

The default MDT must be the same that is configured on all routers that belong to the same VPN. The source IP address is the address that you use to source the BGP sessions.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *VRF_NAME*
3. **mdt default** *address*

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch#configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**vrf context** *VRF_NAME* **Example:** `switch(config)#vrf context vrf1`	Configures the VRF.
Step 3	**mdt default** *address* **Example:** `switch(config)#mdt default 232.0.0.1`	Configures the multicast address range for data MDTs for a VRF as follows: • A tunnel interface is created as a result of this command. • By default, the destination address of the tunnel header is the address argument.

Configuring MDT SAFI for a VRF

By default, MDT subsequent address family identifiers (SAFI) for a VRF are enforced. If desired, you can configure MDT to interoperate with peers that do not support MDT SAFI.

Procedure

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch#configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**vrf context** *VRF_NAME*
	Example:
	`switch(config)#vrf context vrf1`
	`switch(config-vrf)#`
		Configures the VRF.

Step 3	**no mdt enforce-bgp-mdt-safi** **Example:** `switch(config-vrf)#no mdt enforce-bgp-mdt-safi`	Enables MDT to interoperate with peers that do not support MDT SAFI. Initially only the (*,G) entry for the default MDT group is populated if it falls within the Any Source Multicast (ASM) range. Then later, based on traffic, the (S,G) entries are learned like regular ASM routes. Removing the **no** option from the command enforces the use of MDT SAFI for the specified VRF.

Configuring MDT address family in BGP for MVPNs

You can configure an MDT address family session on PE routers to establish MDT peering sessions for MVPNs.

Use the **address-family ipv4 mdt** command under neighbor mode to configure an MDT address-family session. MDT address-family sessions are used to pass the source PE address and MDT address to PIM using BGP MDT Subaddress Family Identifier (SAFI) updates.

Before you begin

Before MVPN peering can be established through an MDT address family, you must configure MPLS in the BGP network and multiprotocol BGP on PE routers that provide VPN services to CE routers.

Procedure

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch#configure terminal`
	`switch(config)#`
		Enters global configuration mode.

	Command or Action	Purpose
Step 2	**feature bgp** *as-number* **Example:** `switch(config)#feature bgp 65635`	Enters switch configuration mode and creates a BGP routing process.

Step 3	**vrf context** *VRF_NAME*
	Example:
	`switch(config)#vrf context vpn1`
	`switch(config-vrf)#`
		Defines a VPN routing instance identified by vrf-name and enters VRF configuration mode. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.

Step 4	**rd** *route-distinguisher* **Example:** `switch(config-vrf)#rd 1.2.1`	Assigns a route distinguisher to the VRF vrf-name. The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix. You can enter an RD in either of these formats: • 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3 • 32-bit IP address: your 16-bit number, for example, 192.0.2.1:1

Step 5	**address-family ipv4 unicast**
	Example:
	`switch(config-vrf)#address-family ipv4 unicast`
	`switch(config-vrf-af)#`
		Specifies the IPv4 address family type and enters address family configuration mode

Step 6	**route-target import** *route-target-ext-community* **Example:** `switch(config-vrf-af)# route-target import 1.0.1`	Specifies a route-target extended community for a VRF. The **import** keyword imports routing information from the target VPN extended community. The *route-target-ext-community* argument adds the route-target extended community attributes to the VRF list of import route-target extended communities. You can enter the *route-target-ext-community* argument in either of these formats: • 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3 • 32-bit IP address: your 16-bit number, for example, for example, 192.0.2.1:1
Step 7	**route-target export** *route-target-ext-community* **Example:** `switch(config-vrf-af)# route-target export 1.0.1`	Specifies a route-target extended community for a VRF. The **export** keyword imports routing information from the target VPN extended community. The *route-target-ext-community* argument adds the route-target extended community attributes to the VRF list of import route-target extended communities. You can enter the *route-target-ext-community* argument in either of these formats:

	Command or Action	Purpose
		• 16-bit or 32-bit AS number: your 32-bit number, for example, 1.2:3 • 32-bit IP address: your 16-bit number, for example, for example, 192.0.2.1:1

Step 8	**router bgp** *as-number*
	Example:
	`switch(config)#router bgp 1.1`
	`switch(config-router)#`
		Configures a BGP routing process and enters router configuration mode. The as-number argument indicates the number of an autonomous system that identifies the router to other BGP routers and tags the routing information passed along. 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.

Step 9	**address-family ipv4 mdt** **Example:** `switch(config-router)#address-family ipv4 mdt`	Enters IPv4 MDT address family configuration mode.

Step 10	**address-family** {**vpn4**} [**unicast**]
	Example:
	`switch(config-router-af)# address-family vpnv4`
	`switch(config-router-af)#`
		Enters address family configuration mode for configuring routing sessions, such as BGP, that use standard VPNv4 or VPNv6 address prefixes. The optional **unicast** keyword specifies VPNv4 or VPNv6 unicast address prefixes.

Step 11	**address-family** {**ipv4**} **unicast**
	Example:
	`switch(config-router-af)# address-family ipv4 unicast`
	`switch(config-router-af)#`
		Enters address family configuration mode for configuring routing sessions that use standard IPv4 or IPv6 address prefixes.

Step 12	**neighbor** *neighbor-address* **Example:** `switch(config-switch-af)# neighbor 192.168.1.1`	Enters neighbor configuration mode.
Step 13	**update source** *interface* **Example:** `switch(config-switch-neighbor)# update-source loopback 1`	Sets the update source as loopback1.
Step 14	**address-family ipv4 mdt** **Example:** `switch(config-router-neighbor)# address-family ipv4 mdt`	Enters address family configuration mode to create an IP MDT address family session.
Step 15	**send-community extended** **Example:** `switch(config-router-neighbor-af)#send-community extended`	Specifies that extended communities attribute should be sent to a BGP neighbor.

	Command or Action	Purpose
Step 16	**show bgp** {**ipv4**} **unicast neighbors vrf***VRF_NAME* **Example:** `switch(config-router-neighbor-af)#show bgp ipv4 unicast neighbors vrf vpn1`	Displays information about BGP neighbors. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 17	**copy running-config startup-config** **Example:** `switch(config-router-neighbor-af)#copy running-config startup-config`	Copies the running configuration to the startup configuration.

Configuring Data MDT

You can configure a data MDT. Multicast groups that are used to create the data MDT are dynamically chosen from a pool of configured IP addresses. If the number of streams is greater than the maximum number of data MDTs per VRF per PE, multiple streams share the same data MDT.

Before you begin

Before configuring a data MDT, you must configure the default MDT on the VRF.

SUMMARY STEPS

1. **configure terminal**
2. **vrf context** *VRF_NAME*
3. **mdt data** *prefix* [**immediate-switch**] [**route-map** *policy-name*]
4. **exit**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch#configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**vrf context** *VRF_NAME* **Example:** `switch#ip vrf vrf1`	Enters VRF configuration mode and defines the VPN routing instance by assigning a VRF name.
Step 3	**mdt data** *prefix* [**immediate-switch**] [**route-map** *policy-name*] **Example:** `switch(config-vrf)# mdt data 225.1.1.1/32 immediate-switch route-map test` **Example:**	Specifies a range of values as follows: • The *prefix* specifies the range of addresses to be used in the data MDT pool. • The *policy-name* defines a policy file that defines which customer data streams should be considered for switching onto the data MDT.

	Command or Action	Purpose
	`switch(config-vrf)# mdt data 225.1.1.1/32 route-map test`	**Note** Entering this command with or without the immediate-switch option has the same effect.
Step 4	**exit** **Example:** `switch(config)#exit`	Returns to global configuration mode.

Verifying the MVPN configuration

To display the MVPN configuration, perform one of the following tasks:

Table 8: Verifying the MVPN Configuration

Command	Purpose
show interface	Displays details of an interface.
show ip mroute vrf	Displays multicast routes.
show ip pim event-history mvpn	Displays the details of the MVPN event history logs.
show ip pim mdt	Displays the details of MTI tunnels created by MVPN.
show ip pim mdt receive vrf vrf-name	Displays the mapping of the customer source, the customer group to data MDT source, and the data MDT group on the receiving side.
show ip pim mdt send vrf vrf-name	Displays the mapping of the customer source, the customer group to data MDT source, and the data MDT group on the sending side.
show ip pim neighbor	Displays details of established PIM neighbors.
show ip route detail	Displays the details of the unicast routing tables.
show mvpn bgp mdt-safi	Displays the BGP MDT SAFI database in MVPN.
show mvpn mdt encap vrf *vrf*	Displays the encapsulation table in MVPN. This table indicates how MVPN packets are encapsulated when sent out on the default vrf.
show mvpn mdt route	Displays details of the default and MDT routes. This data determines how customer data and control traffic is sent on the default VRF.
show routing [ip] **multicast mdt encap**	Displays the encapsulation table in the MRIB. This table indicates how MVPN packets are encapsulated when sent out on the default vrf.

Configuration Examples for MVPNs

The following example shows how to configure an MVPN with two contexts:

```
vrf context vpn1
  ip pim rp-address 10.10.1.2 -list 224.0.0.0/8
  ip pim ssm range 232.0.0.0/8
  rd auto
  mdt default 232.1.1.1
  mdt source loopback1
  mdt data 225.122.111.0/24 immediate-switch
vrf context vpn4
  ip pim rp-address 10.10.4.2 -list 224.0.0.0/8
  ip pim ssm range 232.0.0.0/8
  mdt default 235.1.1.1
  mdt asm-use-shared-tree
ip pim rp-address 10.11.0.2 -list 224.0.0.0/8
ip pim rp-address 10.11.0.4 -list 235.0.0.0/8
ip pim ssm range 232.0.0.0/8
```

The following example shows how to assign to the VPN routing instance a VRF named blue. The MDT default for a VPN VRF is 10.1.1.1, and the multicast address range for MDTs is 10.1.2.0 with wildcard bits of 0.0.0.3:

```
Vrf context blue
mdt data 225.122.111.0/24 immediate-switch
```

CHAPTER 9

InterAS Option B

This chapter explains the different InterAS option B configuration options. The available options are InterAS option B, InterAS option B (with RFC 3107), and InterAS option B lite. The InterAS option B (with RFC 3107) implementation ensures complete IGP isolation between the data centers and WAN. When BGP advertises a particular route to ASBR, it also distributes the label which is mapped to that route.

Information About InterAS

An autonomous system (AS) is a single network or group of networks that is controlled by a common system administration group and using a single, clearly defined protocol. In many cases, virtual private networks (VPNs) extend to different ASes in different geographical areas. Some VPNs must extend across multiple service providers; these VPNs are called overlapping VPNs. The connection between ASes must be seamless to the customer, regardless of the complexity or location of the VPNs.

InterAS and ASBR

Separate ASes from different service providers can communicate by exchanging information in the form of VPN IP addresses. The ASBRs use EBGP to exchange that information. The IBGP distributes the network layer information for IP prefixes throughout each VPN and each AS. The following protocols are used for sharing routing information:

- Within an AS, routing information is shared using IBGP.

- Between ASes, routing information is shared using EBGP. EBGP allows service providers to set up an interdomain routing system that guarantees loop-free exchange of routing information between separate ASes.

The primary function of EBGP is to exchange network reachability information between ASes, including information about the list of AS routes. The ASes use EBGP border edge routers to distribute the routes, which includes label-switching information. Each border edge router rewrites the next-hop and MPLS labels.

InterAS configuration supported in this MPLS VPN can include an interprovider VPN, which is MPLS VPNs that include two or more ASes, connected by separate border edge routers. The ASes exchange routes use EBGP, and no IBGP or routing information is exchanged between the ASes.

Exchanging VPN Routing Information

ASes exchange VPN routing information (routes and labels) to establish connections. To control connections between ASes, the PE routers and EBGP border edge routers maintain a label forwarding information base (LFIB). The LFIB manages the labels and routes that the PE routers and EBGP border edge routers receive during the exchange of VPN information.

The ASes use the following guidelines to exchange VPN routing information:

- Routing information includes:
  - The destination network.
  - The next-hop field associated with the distributing router.
  - A local MPLS label
- A route distinguisher (RD1) is part of a destination network address. It makes the VPN IP route globally unique in the VPN service provider environment.

The ASBRs are configured to change the next-hop when sending VPN NLRIs to the IBGP neighbors. Therefore, the ASBRs must allocate a new label when they forward the NLRI to the IBGP neighbors.

InterAS Options

Nexus 3600 series switches support the following InterAS options:

- **InterAS option A** - In an interAS option A network, autonomous system border router (ASBR) peers are connected by multiple subinterfaces with at least one interface VPN that spans the two ASes. These ASBRs associate each subinterface with a VPN routing and forwarding (VRF) instance and a BGP session to signal unlabeled IP prefixes. As a result, traffic between the back-to-back VRFs is IP. In this scenario, the VPNs are isolated from each other and, because the traffic is IP Quality of Service (QoS) mechanisms that operate on the IP traffic can be maintained. The downside of this configuration is that one BGP session is required for each subinterface (and at least one subinterface is required for each VPN), which causes scalability concerns as the network grows.
- **InterAS option B** - In an interAS option B network, ASBR ports are connected by one or more subinterfaces that are enabled to receive MPLS traffic. A Multiprotocol Border Gateway Router (MP-BGP) session distributes labeled VPN prefixes between the ASBRs. As a result, the traffic that flows between the ASBRs is labeled. The downside of this configuration is that, because the traffic is MPLS, QoS mechanisms that are applied only to IP traffic cannot be carried and the VRFs cannot be isolated. InterAS

option B provides better scalability than option A because it requires only one BGP session to exchange all VPN prefixes between the ASBRs. Also, this feature provides nonstop forwarding (NSF) and Graceful Restart. The ASBRs must be directly connected in this option.

Some functions of option B are noted below:

- You can have an IBGP VPNv4/v6 session between Nexus 3600 series switches within an AS and you can have an EBGP VPNv4/v6 session between data center edge routers and WAN routers.
- There is no requirement for a per VRF IBGP session between data center edge routers, like in the lite version.
- – LDP distributes IGP labels between ASBRs.
- **InterAS option B (with BGP-3107 or RFC 3107 implementation)**
- You can have an IBGP VPNv4/v6 implementation between Nexus 3600 platform switches within an AS and you can have an EBGP VPNv4/v6 session between data center edge routers and WAN routers.
- BGP-3107 enables BGP packets to carry label information without using LDP between ASBRs.
- The label mapping information for a particular route is piggybacked in the same BGP update message that is used to distribute the route itself.
- When BGP is used to distribute a particular route, it also distributes an MPLS label which is mapped to that route. Many ISPs prefer this method of configuration since it ensures complete IGP isolation between the data centers.
- **InterAS option B lite** – Support for the InterAS option B feature is restricted in the Cisco NX-OS 6.2(2) release. Details are noted in the Configuring InterAS Option B (lite version) section.

Guidelines and Limitations for Configuring InterAS Option B

The InterAS option B feature is not supported with BGP confederation AS. However, the Option B implementation is supported on Cisco Nexus 3600 platform switches.

Configuring the Switch for InterAS Option B

You enable certain features on the switch to run InterAS option B.

Before you begin

The install feature-set mpls command is available only in the default VDC, and you must enable it in default VDC.

Configure VRFs on the DC edge switches with following steps:

SUMMARY STEPS

1. **configure terminal**
2. **install feature-set mpls**

3. **feature mpls ldp**
4. **feature mpls l3vpn**
5. **feature bgp**
6. **vrf-context** *vrf-name*
7. **rd** *route-target-ext-community*
8. **address-family {ipv4 | ipv6} unicast**
9. **route-target {import | export}** *route-target-ext-community*
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**install feature-set mpls** **Example:** `switch(config)# install feature-set mpls`	Installs the MPLS feature set in the default VDC. **Note** You can only install and enable MPLS in the default VDC. Use the no form of this command to uninstall the MPLS feature set
Step 3	**feature mpls ldp** **Example:** `switch(config)# feature mpls ldp`	Enables the MPLS LDP feature on the device.. **Note** When the MPLS LDP feature is disabled on the device, no LDP commands are available.
Step 4	**feature mpls l3vpn** **Example:** `switch(config)# feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature.
Step 5	**feature bgp** **Example:** `switch(config)# feature bgp`	Enables the BGP feature.
Step 6	**vrf-context** *vrf-name* **Example:** `switch(config)# vrf context VPN1`	Defines the VPN routing instance by assigning a VRF name and enters VRF configuration mode. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 7	**rd** *route-target-ext-community* **Example:** `switch(config-vrf)# rd100:1`	Configures the route distinguisher. The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix.
Step 8	**address-family {ipv4 | ipv6} unicast** **Example:** `switch(config-vrf)# address-family ipv4 unicast`	Specifies the IPv4 or IPv6 address family type and enters address family configuration mode.

	Command or Action	Purpose
Step 9	**route-target {import | export}** *route-target-ext-community* **Example:** `switch(config-vrf-af-ip4)# route-target import 1:1`	Specifies a route-target extended community for a VRF as follows: • The import keyword imports routing information from the target VPN extended community. • The export keyword exports routing information to the target VPN extended community. • The route-target-ext-community argument adds the route-target extended community attributes to the VRF's list of import or export route-target extended communities.
Step 10	**copy running-config startup-config** **Example:** `switch(config-vrf-af-ip4)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring BGP for InterAS Option B

Configure DC Edge switches with IBGP & EBGP VPNv4/v6 with the following steps:

Before you begin

To configure BGP for InterAS option B, you need to enable this configuration on both the IBGP and EBGP sides. Refer to Figure 1 for reference.

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **neighbor** *ip-address*
4. **remote-as** *as-number*
5. **address-family {vpnv4 | vpnv6} unicast**
6. **send-community {both | extended}**
7. **retain route-target all**
8. **vrf** *vrf-name*
9. **address-family {ipv4 | ipv6} unicast**
10. **exit**
11. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**router bgp** *as-number* **Example:** `switch(config)# router bgp 100`	Enters the router BGP configuration mode and assigns an autonomous system (AS) number to the local BGP speaker device.
Step 3	**neighbor** *ip-address* **Example:** `switch(config-router)# neighbor 10.0.0.2`	Adds an entry to the BGP or multiprotocol BGP neighbor table, and enters router BGP neighbor configuration mode.
Step 4	**remote-as** *as-number* **Example:** `switch(config-router-neighbor)# remote-as 200`	The as-number argument specifies the autonomous system to which the neighbor belongs.
Step 5	**address-family {vpnv4 | vpnv6} unicast** **Example:** `switch(config-router-neighbor)# address-family vpnv4 unicast`	Enters address family configuration mode for configuring IP VPN sessions.

Step 6	**send-community {both | extended}**
	Example:
	`switch(config-router-neighbor-af)# send-community both`
		Specifies that a communities attribute should be sent to both BGP neighbors.

Step 7	**retain route-target all** **Example:** `switch(config-router-neighbor-af)# retain route-target all`	(Optional). Retains VPNv4/v6 address configuration on the ASBR without VRF configuration. **Note** If you have a VRF configuration on the ASBR, this command is not required.
Step 8	**vrf** *vrf-name* **Example:** `switch(config-router-neighbor-af)# vrf VPN1`	Associates the BGP process with a VRF.
Step 9	**address-family {ipv4 | ipv6} unicast** **Example:** `switch(config-router-vrf)# address-family ipv4 unicast`	Specifies the IPv4 or IPv6 address family and enters address family configuration mode.
Step 10	**exit** **Example:** `switch(config-vrf-af)# exit`	Exits IPv4 address family.

	Command or Action	Purpose
Step 11	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring the Switch for InterAS Option B (with RFC 3107 implementation)

You enable certain features on the switch to run InterAS option B.

Before you begin

Configure VRFs on the DC edge switches with following steps:

SUMMARY STEPS

1. **configure terminal**
2. **install feature-set mpls**
3. **feature mpls ldp**
4. **feature mpls l3vpn**
5. **feature bgp**
6. **vrf-context** *vrf-name*
7. **rd** *route-distinguisher*
8. **address-family {ipv4 | ipv6} unicast**
9. **route-target {import | export}** *route-target-ext-community*
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**install feature-set mpls** **Example:** `switch(config)# install feature-set mpls`	Installs the MPLS feature set in the default VDC. **Note** You can only install and enable MPLS in the default VDC. Use the no form of this command to uninstall the MPLS feature set
Step 3	**feature mpls ldp** **Example:** `switch(config)# feature mpls ldp`	Enables the MPLS LDP feature on the device.. **Note** When the MPLS LDP feature is disabled on the device, no LDP commands are available.

	Command or Action	Purpose
Step 4	**feature mpls l3vpn** **Example:** `switch(config)# feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature.
Step 5	**feature bgp** **Example:** `switch(config)# feature bgp`	Enables the BGP feature.
Step 6	**vrf-context** *vrf-name* **Example:** `switch(config)# vrf context VPN1`	Defines the VPN routing instance by assigning a VRF name and enters VRF configuration mode. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 7	**rd** *route-distinguisher* **Example:** `switch(config-vrf)# rd100:1`	Configures the route distinguisher. The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix.
Step 8	**address-family {ipv4 | ipv6} unicast** **Example:** `switch(config-vrf)# address-family ipv4 unicast`	Specifies the IPv4 or IPv6 address family type and enters address family configuration mode.
Step 9	**route-target {import | export}** *route-target-ext-community* **Example:** `switch(config-vrf-af-ip4)# route-target import 1:1`	Specifies a route-target extended community for a VRF as follows: • The import keyword imports routing information from the target VPN extended community. • The export keyword exports routing information to the target VPN extended community. • The route-target-ext-community argument adds the route-target extended community attributes to the VRF's list of import or export route-target extended communities.
Step 10	**copy running-config startup-config** **Example:** `switch(config-vrf-af-ip4)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring BGP for InterAS Option B (with RFC 3107 implementation)

Configure DC Edge switches with IBGP & EBGP VPNv4/v6 along with BGP labeled unicast family with following steps:

Before you begin

Ensure that you are in the correct VDC (or use the **switchto vdc** command).

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **address-family {vpnv4 | vpnv6} unicast**
4. **redistribute direct route-map** *tag*
5. **allocate-label all**
6. **exit**
7. **neighbor** *ip-address*
8. **remote-as** *as-number*
9. **address-family {ipv4|ipv6} labeled-unicast**
10. **retain route-target all**
11. **exit**
12. **neighbor** *ip-address*
13. **remote-as** *as-number*
14. **address-family {vpnv4|vpnv6} unicast**
15. **exit**
16. **address-family {vpnv4|vpnv6} unicast**
17. **Repeat the process with ASBR2**
18. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**router bgp** *as-number* **Example:** ` switch(config)# router bgp 100`	Enters the router BGP configuration mode and assigns an autonomous system (AS) number to the local BGP speaker device.
Step 3	**address-family {vpnv4 | vpnv6} unicast** **Example:** `switch(config-router-neighbor)# address-family vpnv4 unicast`	Enters address family configuration mode for configuring IP VPN sessions.
Step 4	**redistribute direct route-map** *tag* **Example:** ` switch(config-router-af)# redistribute direct route-map loopback`	Redistributes directly connected routes using the Border Gateway Protocol.

	Command or Action	Purpose
Step 5	**allocate-label all** **Example:** `switch(config-router-af)# allocate-label all`	Configures ASBRs with the BGP labeled unicast address family to advertise labels for the connected interface.
Step 6	**exit** **Example:** `switch(config-router-af)# exit`	Exits address family router configuration mode and enters router BGP configuration mode.
Step 7	**neighbor** *ip-address* **Example:** `switch(config-router)# neighbor 10.1.1.1`	Configures the BGP neighbour's IP address, and enters router BGP neighbour configuration mode.
Step 8	**remote-as** *as-number* **Example:** `switch(config-router-neighbor)# remote-as 100`	Specifies the BGP neighbour's AS number.
Step 9	**address-family {ipv4|ipv6} labeled-unicast** **Example:** `switch(config-router-neighbor)# address-family ipv4 labeled-unicast`	Configures the ASBR with the BGP labeled unicast address family to advertise labels for the connected interface. **Note** This is the command that implements RFC 3107.
Step 10	**retain route-target all** **Example:** `switch(config-router-neighbor-af)# retain route-target all`	(Optional). Retains VPNv4/v6 address configuration on the ASBR without VRF configuration. **Note** If you have a VRF configuration on the ASBR, this command is not required.
Step 11	**exit** **Example:** `Switch(config-router-neighbor-af)# exit`	Exits router BGP neighbour address family configuration mode and returns to router BGP configuration mode.
Step 12	**neighbor** *ip-address* **Example:** `switch(config-router)# neighbor 10.1.1.1`	Configures a loopback IP address, and enters router BGP neighbor configuration mode..
Step 13	**remote-as** *as-number* **Example:** `switch(config-router-neighbor)# remote-as 100`	Specifies the BGP neighbour's AS number.
Step 14	**address-family {vpnv4|vpnv6} unicast** **Example:** `switch(config-router-vrf)# address-family ipv4 unicast`	Configures the ASBR with the BGP VPNv4 unicast address family.

	Command or Action	Purpose
Step 15	**exit** **Example:** `switch(config-vrf-af)# exit`	Exits IPv4 address family.
Step 16	**address-family {vpnv4|vpnv6} unicast** **Example:** `switch(config-router-vrf)# address-family ipv4 unicast`	Configures the ASBR with the BGP VPNv4 unicast address family.
Step 17	**Repeat the process with ASBR2**	Configures ASBR2 with option B (RFC 3107) settings and implements complete IGP isolation between the two data centers DC1 and DC2.
Step 18	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Creating an ACL to filter LDP connections between the ASBRs (RFC 3107 implementation)

SUMMARY STEPS

1. **configure terminal**
2. **ip access-list** *name*
3. **[** sequence-number **]deny tcp any any eq** *packet-length*
4. **[** sequence-number **] deny tcp any eq** *packet-length* **any**
5. **[** sequence-number **] deny udp any any eq** *packet-length*
6. **[** sequence-number **] deny udp any eq** *packet-length* **any**
7. **[** sequence-number **] permit ip any any**
8. **exit**
9. **interface** *type number*
10. **mpls ip**
11. **ip access-group** *name* **in**
12. **ip access-group** *name* **out**
13. **end**

DETAILED STEPS

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

	Command or Action	Purpose

	`switch# configure terminal`
	`switch(config)#`	

Step 2	**ip access-list** *name* **Example:** `switch(config)# ip access-list LDP`	Creates an access list and enters ACL configuration mode.
Step 3	**[** sequence-number **]deny tcp any any eq** *packet-length* **Example:** `switch(config-acl)# 10 deny tcp any any eq 646`	Executes the ACL instruction as per the specified sequence.
Step 4	**[** sequence-number **] deny tcp any eq** *packet-length* **any** **Example:** `switch(config-acl)# 20 deny tcp any eq 646 any`	Executes the ACL instruction as per the specified sequence.
Step 5	**[** sequence-number **] deny udp any any eq** *packet-length* **Example:** `switch(config-acl)# 30 deny udp any any eq 646`	Executes the ACL instruction as per the specified sequence.
Step 6	**[** sequence-number **] deny udp any eq** *packet-length* **any** **Example:** `switch(config-acl)# 20 deny udp any eq 646 any`	Executes the ACL instruction as per the specified sequence.
Step 7	**[** sequence-number **] permit ip any any** **Example:** `switch(config-acl)# 50 permit ip any any`	Executes the ACL instruction as per the specified sequence.
Step 8	**exit** **Example:** `switch(config-acl)# exit`	Exits ACL configuration mode and enters global configuration mode.
Step 9	**interface** *type number* **Example:** `switch(config)# interface ethernet 2/20`	Enters interface configuration mode.
Step 10	**mpls ip** **Example:** `switch(config-if)# mpls ip`	Configures MPLS hop-by-hop forwarding on this interface.
Step 11	**ip access-group** *name* **in** **Example:** `switch(config-if)# ip access-group LDP in`	Specifies that the ACL (named LDP created in the earlier steps) be applied to inbound traffic on the interface.

	Command or Action	Purpose
Step 12	**ip access-group** *name* **out** **Example:** `switch(config-if)# ip access-group LDP out`	Specifies that the ACL (named LDP created in the earlier steps) be applied to the outbound traffic on the interface.

Step 13	**end**
	Example:
	`switch(config-if)# end`
		Exits interface configuration mode and returns to the privileged EXEC mode

Configuring InterAS Option B (lite Version)

Guidelines and Limitations for Configuring InterAS Option B lite

- The aggregation switch supports only local VRFs, and Nexus devices within an autonomous system (AS) are connected through a VRF implementation.
- Routes learned from the IBGP peer are not sent to the EBGP peer and routes learned from an EBGP peer are not sent to IBGP VPNv4/VPNv6 peers.
- The interAS option B with MP-BGP on the EBGP side does not work with MP-BGP on the IBGP side. One interface goes to the core and one interface goes to the Layer 3 VPN.
- MP-BGP Layer 3 VPN does not work within an AS.

Configuring the Switch for InterAS Option B (lite version)

You enable certain features on the switch to run interAS option B.

Before you begin

The install feature-set mpls command is available only in the default VDC, and you must enable it in default VDC.

SUMMARY STEPS

1. **configure terminal**
2. **install feature-set mpls**
3. **feature mpls ldp**
4. **feature mpls l3vpn**
5. **feature bgp**
6. **vrf-context** *vrf-name*
7. **rd** *route-distinguisher*
8. **address-family {ipv4 | ipv6} unicast**
9. **route-target {import | export}** *route-target-ext-community*
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

Step 2	**install feature-set mpls** **Example:** `switch(config)# install feature-set mpls`	Installs the MPLS feature set in the default VDC. **Note** You can only install and enable MPLS in the default VDC. Use the no form of this command to uninstall the MPLS feature set.
Step 3	**feature mpls ldp** **Example:** `switch(config)# feature mpls ldp`	Enables the MPLS LDP feature on the device. When the MPLS LDP feature is disabled on the device, no LDP commands are available.
Step 4	**feature mpls l3vpn** **Example:** `switch(config)# feature mpls l3vpn`	Enables the MPLS Layer 3 VPN feature.
Step 5	**feature bgp** **Example:** `switch(config)# feature bgp`	Enables the BGP feature.
Step 6	**vrf-context** *vrf-name* **Example:** `switch(config)# vrf-context VPN1`	Defines the VPN routing instance by assigning a VRF name and enters VRF configuration mode. The vrf-name argument is any case-sensitive, alphanumeric string up to 32 characters.
Step 7	**rd** *route-distinguisher* **Example:** `switch(config-vrf)# rd 100:1`	Configures the route distinguisher. The route-distinguisher argument adds an 8-byte value to an IPv4 prefix to create a VPN IPv4 prefix.
Step 8	**address-family {ipv4 | ipv6} unicast** **Example:** `switch(config-vrf)# address-family ipv4 unicast`	Specifies the IPv4 or IPv6 address family type and enters address family configuration mode.
Step 9	**route-target {import | export}** *route-target-ext-community* **Example:**	Specifies a route-target extended community for a VRF as follows:

	Command or Action	Purpose
	`switch(config-vrf-af-ip4)# route-target import 1:1`	**Note** • The **import** keyword imports routing information from the target VPN extended community. • The **export** keyword exports routing information to the target VPN extended community. • The *route-target-ext-community* argument adds the route-target extended community attributes to the VRF's list of import or export route-target extended communities.
Step 10	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Configuring BGP for InterAS Option B (lite Version)

Configure EBGP VPNv4/v6 on the DC Edge switches using the following steps:

SUMMARY STEPS

1. **configure terminal**
2. **router bgp** *as-number*
3. **neighbor** *ip-address*
4. **remote-as** *as-number*
5. **address-family {vpnv4 | vpnv6} unicast**
6. **send-community {both | extended}**
7. **vrf** *vrf-name*
8. **address-family {ipv4 | ipv6} unicast**
9. **exit**
10. **copy running-config startup-config**

DETAILED STEPS

	Command or Action	Purpose

Step 1	**configure terminal**
	Example:
	`switch# configure terminal`
	`switch(config)#`
		Enters global configuration mode.

	Command or Action	Purpose
Step 2	**router bgp** *as-number* **Example:** `switch(config)# router bgp 100`	Enters the router BGP configuration mode and assigns an autonomous system (AS) number to the local BGP speaker device.
Step 3	**neighbor** *ip-address* **Example:** `switch(config-router)# neighbor 10.0.0.2`	Adds an entry to the BGP or multiprotocol BGP neighbor table, and enters router BGP neighbor configuration mode.
Step 4	**remote-as** *as-number* **Example:** `switch(config-router-neighbor)# remote-as 200`	The as-number argument specifies the autonomous system to which the neighbor belongs.
Step 5	**address-family {vpnv4 | vpnv6} unicast** **Example:** `switch(config-router-neighbor)# address-family vpnv4 unicast`	Enters address family configuration mode for configuring IP VPN sessions.

Step 6	**send-community {both | extended}**
	Example:
	`switch(config-router-neighbor-af)# send-community both`
		Specifies that a communities attribute should be sent to both BGP neighbors.

Step 7	**vrf** *vrf-name* **Example:** `switch(config-router-neighbor-af)# vrf VPN1`	Associates the BGP process with a VRF.
Step 8	**address-family {ipv4 | ipv6} unicast** **Example:** `switch(config-router-vrf)# address-family ipv4 unicast`	Specifies the IPv4 or IPv6 address family and enters address family configuration mode.
Step 9	**exit** **Example:** `switch(config-vrf-af)# exit`	Exits IPv4 address family.
Step 10	**copy running-config startup-config** **Example:** `switch(config-router-vrf)# copy running-config startup-config`	(Optional) Copies the running configuration to the startup configuration.

Verifying InterAS Option B Configuration

To verify InterAS option B configuration information, perform one of the following tasks:

Command	Purpose
show bgp { vpnv4 | vpnv6 } unicast [*ip-prefix/length* [**neighbors** *neighbor*]] {**vrf**{*vrf-name* | **all** } | **rd** *route-distinguisher* }	Displays VPN routes from the BGP table.
show bgp ipv6 unicast [**vrf***vrf-name*]	Displays information about BGP on a VRF for 6VPE.
show forwarding { ip | ipv6 } route vrf *vrf-name*	Displays the IP forwarding table that is associated with a VRF. Check that the loopback addresses of the local and remote CE routers are in the routing table of the PE routers.
show { ip | ipv6 } bgp[**vrf** *vrf-name*]	Displays information about BGP on a VRF..
show ip route[*ip-address* [mask]] [*protocol*] **vrf** *vrf-name*	Displays the current state of the routing table. Use the ip-address argument to verify that CE1 has a route to CE2. Verify the routes learned by CE1. Make sure that the route for CE2 is listed.
show {**ip** | **ipv6**} **routevrf** *vrf-name*	Displays the IP routing table that is associated with a VRF. Check that the loopback addresses of the local and remote CE routers are in the routing table of the PE routers.
show running-config bgp	Displays the running configuration for BGP.
show running-config vrf *vrf-name*	Displays the running configuration for VRFs.
show vrf *vrf-name* **interface** *if-type*	Verifies the route distinguisher (RD) and interface that are configured for the VRF.
trace *trace destination* **vrf** *vrf-name*	Discovers the routes that packets take when traveling to their destination. The trace command can help isolate a problem if two routers cannot communicate.

Configuration Examples for Configuring InterAS Option B

This example shows how to configure InterAS Option B

```
!--Configure VRFs on the DC edge switches --!

configure terminal
install feature-set mpls
feature mpls ldp
feature mpls l3vpn
feature bgp
vrf context VPN1
rd 100:1
address-family ipv4 unicast
route-target import 1:1
copy running-config startup-config

!--Configure DC Edge switches with IBGP & EBGP VPNv4/v6 --!
```

```
configure terminal
router bgp 100
neighbor 10.0.0.2
remote-as 200
address-family vpnv4 unicast
send-community both
retain route-target all
vrf VPN1
address-family ipv4 unicast
exit
copy running-config startup-config
```

This example shows how to configure InterAS Option B (RFC 3107)

```
!--Configure VRFs on the DC edge switches --!

configure terminal
install feature-set mpls
feature mpls ldp
feature mpls l3vpn
feature bgp
vrf context VPN1
rd 100:1
address-family ipv4 unicast
route-target import 1:1
copy running-config startup-config

!--Configure DC Edge switches with IBGP & EBGP VPNv4/v6 --!

configure terminal
router bgp 100
address-family ipv4 unicast
redistribute direct route-map loopback
allocate-label all
exit
neighbor 10.1.1.1
remote-as 100
address-family ipv4 labeled-unicast
retain route-target all
exit
neighbor 1.1.1.1
remote-as 100
address-family vpnv4 unicast
address-family vpnv6 unicast
!--Repeat the process with ASBR2. --!
copy running-config startup-config

!--Creating an ACL to filter LDP connection between the ASBRs (RFC 3107 implementation)--!

configure terminal
ip access-list LDP
10 deny tcp any any eq 646
20 deny tcp any eq 646 any
30 deny udp any any eq 646
40 deny udp any eq 646 any
50 permit ip any any
exit
interface ethernet 2/20
mpls ip
ip access-group LDP in
ip access-group LDP out
```

```
end
```

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